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COMMON SENSE FOR GAS-USERS.

BEING

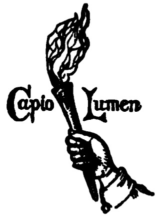
A Catechism of Gas-Lighting.

FOR

HOUSEHOLDERS, MILLOWNERS, AND OTHER LARGE CONSUMERS, GAS-FITTERS, ARCHITECTS, ENGINEERS, ETC.

BY ROBERT WILSON, C.E.,

AUTHOR OF A "TREATISE ON STEAM BOILERS."



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PREFACE.

This book is not written for gas-works engineers, but for gas-fitters, consumers and others, the exercise of whose skill should begin where the work of the gas company's servants usually ends. Had it been the practice for gas companies to continue their work to the burners, this book might never have been written.

Given an adequate supply of good gas at a cheap rate, how can it best be utilised for lighting purposes? This is the problem the writer has here tried to solve, without any pretension to theoretical accuracy.

Abundant evidence to show that reliable information about gas-lighting is much needed may be found in the loud complaints that have been heard, since the following pages were written, about the quality of the gas supplied by the gas companies and corporations of most of the large towns in the United Kingdom.

In Leeds the cry of "bad gas" is likely to result in raising the quality from 16 to 18 candle power. This, in the writer's opinion, is a step in the wrong direction, as no benefit from it will be perceived by those who now have a bad light, due to burning the gas at a high pressure and using the small fish-tail burners so much in vogue; or by those who have scarcely any pressure at all at the meter (for which they have to thank the competition of the late rival gas companies), whereas those consumers who now enjoy a good light, without paying much for it, by using large burners and a low pressure of gas, will perceive the effect of the change only on their blackened ceilings and in the high price of their gas when the coal trade recovers from its present dull state.

In Glasgow the gas, being at least 26 candle power, is much too good for the ordinary run of consumers, who complain that they pay a large price for "a little light and a lot of smoke." For such the gas would be best improved by reducing the quality to the present standard in Leeds. The other day the following appeared in a leader in one of the London daily papers—"A very large quantity of the gas supplied in London is, in spite of the operation of the referees, of vile quality."

It should be unnecessary to say that the quality of the gas has no share in producing the bad light which gives rise to these wide-spread complaints. Bad burners, with either too great or too low a pressure, and the work of ignorant and unscrupulous gas-fitters are to blame in 99 per cent. of cases where the light is bad; and the use of large burners without regulators at the meter, or means of reducing the pressure near the point of ignition, accounts for most of the heavy gas bills.

These complaints, moreover, serve to prove that some of the information contained in the following chapters is much needed, not only by the general public, but also by many writers for the press and others who constitute themselves leaders of the public in matters relating to gas-lighting.

The few simple experiments I have described herein for showing how gas is made and smoke produced, the waste caused by burning gas with small burners at high pressure, and that gas should be burnt at a low pressure to give a good light, can be made by any one, and the necessary apparatus can be found in most households or purchased for a few pence.

The importance of the subject may be gathered from the statement that the loss of light consequent upon the use of bad burners and high pressures of gas in London alone, when calculated upon the gas rental and expressed in money value, cannot be less than £600,000 per annum. The loss in such towns as Liverpool, Manchester, and Glasgow, cannot be less than £120,000 per annum.

It is not to be expected that the amounts here given, if not wasted, would not be spent in gas, since that would be tantamount to saying that the demand for an article would be decreased by reducing the price, which is against all commercial experience.

ROBERT WILSON.

116, Queen Victoria St.,
London, E.C.

A

CATECHISM OF GAS-LIGHTING.

CHAPTER I.

NATURE OF GAS.

1. *What is gas?*

This is best answered by making the following well-known juvenile experiment:—Take a long clay tobacco pipe, fill the bowl nearly to the top with small or powdered household coal, and seal the top with clay or moistened coal ash. Place the pipe bowl thus prepared through the bars into a red-hot fire. In a few minutes a smoky vapour will be seen issuing from the mouthpiece of the pipe. On applying a light this vapour will ignite and you will have a small gas jet.

Deprived of the tarry and other foreign matters which, by imparting their colour, make the gas visible, this vapour is virtually the same invisible gas that is supplied to our houses for lighting.

The pipe bowl here answers to the retorts at the gas works, the stem to the main and service pipes, and the mouthpiece to the burner.

2. *What is the nature of this lighting gas?*

When analysed, it is found to be a very complex substance, but we may consider it simply as a *hydrocarbon*, or chemical compound of carbon and hydrogen.

3. *What is a gas flame?*

It is gas in a state of combustion, and the flame may be described as a bubble of gas, with a non-luminous core and a luminous shell, dependent for its shape upon the direction and form of the orifice of the burner, the force with which the gas is forced through the orifice, and the force and direction of the currents of air that come in contact with the flame.

4. *What is combustion?*

A rapid chemical action accompanied by great heat and light. By applying a light to the invisible gas issuing from a burner, a rapid chemical action between the oxygen of the air, and the hydrogen and also the carbon of the gas is set up, which produces sufficient heat to keep up the process of combustion and gives us light and heat.

5. *To what is the light due?* *

To the incandescence or white heat of the carbon particles in the flame. As the gas rises from the jet, the hydrogen of the hydrocarbon is the first to combine with the oxygen of the air, and forms an invisible vapour of water or steam. This liberates the carbon, which was invisible so long as it was in a state of chemical union with the hydrogen. As the now solid and visible particles of carbon rise in the flame, they become white hot and produce the light for which the gas is used.

If a sufficient quantity of air reaches the carbon *whilst in this highly heated state,* the carbon again becomes invisible, forming *carbonic acid gas* with the oxygen of the air.

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* Davy's theory of the luminosity of flames has been here adopted, as being sufficient to explain the phenomena met with in burning coal gas.

Should, however, the supply of air be insufficient, the particles of carbon rise with the current of air and steam and form smoke, properly so called, and are eventually deposited as soot on the surrounding objects, or, should the carbon particles in the flame be cooled down by strong currents of air before they have attained a white heat, they form smoke, as in the last case, or if they are cooled down by coming in contact with a cold substance they are deposited at once as soot.

6. *How can you prove this?*

1st. To show that smoke may be produced by an insufficient supply of air, fit a piece of cardboard on a burner with a triangle and globe in such a manner that it will exclude the air from below when the globe is on. The flame, that before was steady, will now flicker considerably, and if a pan-lid or wire gauze be gradually approached to the top of the globe so as to exclude the air from above, the flame will become more and more smoky.

2nd. In order to show that cooling the flame will make smoke: 1st, blow gently against the side of the flame in a horizontal direction with a pair of bellows placed 3 or 4 feet distant, and the smoke will become visible against a light background as it rises from the red tongues of the flickering flame caused by each draught of air. 2nd, Press down a cold dinner plate on the flame and it will instantly be coated with fine soot. If the plate is removed quickly, the condensed steam from the combustion of the hydrogen will also be visible as a quickly vanishing film of moisture. 3rd. Surround the flame with a cold iron tube.

7. *What then is required in burning gas for lighting?*

That the gas shall be rich in carbon; that it shall be so burnt that the carbon shall be for a time in the solid state and in a state of the intensest white heat possible, that is, at the highest temperature; and that the carbon shall ultimately combine with the oxygen of the air and not pass off in smoke.

8. *Is it possible to burn the carbon so quickly after its liberation from the hydrogen that it shall unite at once with the oxygen without becoming incandescent and giving out much light?*

Yes. We have said that the flame is a luminous bubble. The combustion takes place at its surface,—that of the hydrogen below, and of the carbon above,—whilst the core is occupied by the gas issuing from the jet. Now, should sufficient air be admitted to the gas, before it issues from the jet, and reach the core of the flame, the carbon will be seized by the oxygen, the instant it is liberated from the hydrogen, and will not appear in the solid state at all. Consequently, we shall only have the light of the hydrogen and carbon in their gaseous state, which gives a very intense heat, but a very feeble light. For heating purposes, the gas should always be burnt in this manner, but never for lighting.

9. *How can you prove that mixing air with gas, before igniting, impairs the lighting power?*

Place a piece of wire gauze over the chimney of an Argand burner, or over the globe (if of suitable shape) of an ordinary burner, and light the mixture of gas and air *over* the gauze, when a blue flame will be visible, giving scarcely any light, but great heat without any smoke under all circumstances, showing the carbon is perfectly consumed. If a sufficient supply of gas, which will vary with the size of chimney or globe, is not maintained, the flame will recede into the chimney and ignite the mixture of air and gas with a slight explosion and burn below.

10. *Then one of the chief points to be observed in the use of gas for lighting is the supply of air?*

Yes, air to the inside and air to the outside of the flame. Either too much or too little fresh air at the surface of the flame will produce smoke, and too much air in the core of the flame will prevent smoke but impair the light.

11. *Is the air supply, and consequently the light influenced by the force with which the gas issues from the burner?*

Yes, to a very great extent. In the case of a naked light—that is, where no chimney or globe is used—the current of gas draws an amount of air both to the inside and outside of the flame proportionate to the velocity with which the current issues from the orifice of the burner. It will also depend upon the direction and shape of the jet to what degree this induced action takes place, and whether any increase of velocity will affect the inside or the outside most. If the jet is mainly vertical, as in a union or fish-tail burner, the action will be far more felt than if it is partially vertical and partially horizontal, as in a slit or bat-wing burner. The starting up of fish-tail burners into a long blue non-luminous flame, with a disagreeable whistling noise, on a sudden increase of pressure, familiar to all who have used these burners at high pressure, is due to this action.

12. *Then gas cannot be burnt efficiently at a high pressure?*

No, and it should never be attempted. This is one of the most important points in the whole subject of gas-lighting.

13. *What effect has too low a pressure?*

When the gas does not issue from the jet with sufficient force to cause a sufficiently strong induced current of air to steady the flame, it is liable to be swayed to and fro by light side currents of air, which are produced by the passing of persons to and fro, opening or closing books, and in fact by every movement of the body, and cause the flame to flicker disagreeably and to smoke. This flickering can be prevented by using globes of a proper form (see p. 79).

14. *Then there is a certain pressure or velocity of gas, or gas consumption, that answers best for each kind of burner?*

Yes, there is a certain rate of efflux, or point of gas consumption, at which each kind and size of burner gives its maximum amount of light with any given kind of gas, and the light will diminish as that consumption is increased or diminished.

15. *As the light is given off chiefly from the surface of the upper portion of the flame, is it not important that this surface should be as large as possible?*

Yes, provided the temperature and incandescence *are as great* in a large flame as a small one.

16. *But is this not always the case?*

No, the incandescence of the carbon particles is more intense the higher the temperature and the more rapidly they are consumed, once they are in the solid state. In order to obtain this high temperature and intense white heat, a sufficiently (but not too) strong draught at the surface of the flame is necessary.

17. *How can this draught be obtained?*

By surrounding the flame with a suitable chimney. This can best be done with an Argand flame, which is circular and allows a cylindrical chimney to be applied. An Argand burner without a chimney gives a long, flickering, reddish light, liable to smoke with the slightest motion of the air. On putting on the chimney the length of the flame falls to about one-half, becoming very white and brilliant, with an immense increase in the lighting power.

18. *What is the cause of this change?*

By increasing the draught and the temperature of the air that reaches the upper portion of the flame, the speed of combustion is increased and the carbon in the gas is made to glow more intensely.

19. *What effect has too great a draught on the flame?*

If the draught of cold air be too great on the outside it will reduce the temperature of the flame, diminish the intensity of the combustion, and consequently reduce the brilliancy of the light, and if sufficiently great will prevent some of the carbon particles from becoming incandescent at all and so produce smoke. Should the current of air reach the core of the flame it will combine too rapidly with the carbon and produce blue flame with little light.

20. *So both a decrease of light and an increase of smoke are produced either by too great or too small a draught?*

Yes; and the higher the quality of the gas, that is, the richer it is in carbon, the more difficult is it to ensure its maximum light being obtained under the varying circumstances of draught and consumption.

21. *Does not rich gas, that is, gas containing a*

large amount of carbon, require a larger supply of air than poorer gas?

Yes; consequently a higher pressure can be used with rich gas, and where the supply of air cannot be increased the size of the orifice through which the gas issues must be reduced, or if the shape of burner should favour the contact of air (as in an Argand) the holes may be increased in size if the gas is allowed to issue at a very low pressure.

22. *Whether is the great alleged waste of gas attributable to too great or too small a supply of air?*

Undoubtedly to too great a supply. Too small a supply betrays itself by flickering and smoking, and calls for its own remedy, but too great a supply, unless when the gas is burned in exposed situations, is seldom suspected.

23. *How is the amount or intensity of light affected by the distance?*

The intensity of light decreases as the square of the distance increases. That is, a flame that sheds light of a certain intensity upon an object at 1 yard distance, will shed light of only $\frac{1}{4}$ that intensity at 2 yards, $\frac{1}{9}$ at 3 yards, $\frac{1}{16}$ at 4 yards, and so on.

24. *How is this explained?*

As the light radiates in all directions from the flame as a centre, it follows that the light which covers exactly 1 square foot at a distance of 1 yard from the flame, will cover 4 square feet at 2 yards, 9 square feet at 3 yards, and 16 square feet at 4 yards. As the light which was concentrated upon 1 square foot at 1 yard distance is now spread over 16 square feet at 4 yards, each square foot gets only $\frac{1}{16}$ the amount of light.

CHAPTER II.

QUALITIES OF GAS.

1. *Is all lighting gas of the same quality?*

By no means. Roughly speaking, it may be divided into two kinds, viz.: "Cannel" gas and "Common" gas.

2. *Where is "Cannel" gas chiefly used?*

Nearly all over Scotland, in Liverpool, Manchester, and other places within easy distance of the Scotch and Wigan "Cannel" coal fields.

3. *Where is common gas used?*

Chiefly in London, Birmingham, Sheffield, Leeds, Newcastle-on-Tyne, and other towns, and is obtained from the bituminous coal of the Durham, Yorkshire, and other coal fields.

4. *Which is the richest kind of gas?*

Cannel gas, but owing to the limited extent of the beds of cannel coal it is much dearer than common gas. Generally speaking, a per-centage of cannel coal is used in the manufacture of common gas to raise its illuminating power up to the required standard, and when an extra amount of light may be suddenly required where there is no means of increasing the quantity of gas.

5. *How is the quality of gas usually determined?*

By its standard of illuminating power, or "candle power" as it is usually called.

6. *What is meant by "candle power?"*

A gas is said to be of say 12 candle power, or 14 candle power, when its quality is such that a consumption of 5 cubic feet per hour with the standard burner, or best descriptions of Argand burner, gives a light equal to 12 or 14 sperm candles—6 to the lb.—each consuming 120 grains per hour; or 5 feet of 12 candle gas is equal to (12 × 120 =) 1440 grains of sperm, and 5 feet of 14 candle gas is equal to (14 × 120 =) 1680 grains of sperm. The standard burner for cannel gas is in some towns a slit burner, and in others a fish-tail.

7. *How is the candle power of gas measured?*

In the testing room by a "photometer." With the help of this apparatus the light of the gas from the standard burner can be accurately compared with the light of the standard candles, and easily read off.

8. *Can the standard candle power be obtained in our houses?*

With cannel gas, as the standard burner is one that can be generally used, the full standard candle power can be obtained, with the same consumption, provided the pressure can be adjusted and the gas has not been vitiated by admixture with air. With common gas, as the standard Argand burners are superior to all others, but cannot be used for general purposes, the greatest amount of light that can be obtained, with the same consumption, is from 70 to 80 per cent. of the standard illuminating power, and this can only be obtained by using check burners, unless some means of reducing the pressure by a regulator or otherwise is employed.

9. *What is the candle power of common gas?*

From 12 to 16 candles.

10. *What is the candle power of cannel gas?*

The gas made from the famous Boghead cannel, the richest mineral for gas-making known, was equal to 40 candles. The candle power varies from this down to 20 candles. The gas from Boghead and the other rich cannels is never used alone, but is usually mixed with poorer gases to improve their illuminating power. An addition of about 1¾ per cent. of Boghead, or 3 per cent. of comparatively inferior but still good cannel gas, will raise the standard from 12 candle to 14 candle gas. The coke, after the gas has been extracted from Boghead cannel, is useless for heating purposes, whilst that from Ramsay's Newcastle and some Wigan and other cannels is nearly as good as that from caking coal for many purposes.

11. *What is the standard of illuminating power usually required?*

The standard varies considerably.

According to the City of London Gas Act, of 1868, (31 & 32 Vict. c. 125, s. 53), "the gas (except cannel gas) supplied by each company, shall (subject to the provisions of this Act) be of an illuminating power as follows. . . . ."

"2nd. On and after the 1st of January, 1870, of an illuminating power of not less than 16 candles."

According to the Gas Act of 1860, (23 & 24 Vict. c. 125, s. 25), in force elsewhere than in London, "the quality of the common gas supplied by any gas company shall be, with respect to the illuminating power, at a distance, as near as may be, of 1,000 yards from the works, such as to produce from an Argand burner having 15 holes and a 7-inch chimney, consuming 5 cubic feet of gas an hour, a light equal in intensity to the light produced by not less than 12 sperm candles of 6 to the pound, each burning 120 grains an hour, and the quality of cannel gas supplied by any gas company shall, with respect to its illuminating power, at the distance aforesaid, be such as to produce from a bats-wing or fish-tail burner consuming 5 cubic feet of gas per hour a light equal in intensity to 20 such sperm candles." By the Gas and Waterworks Facilities Act of 1870, and by the Gasworks Clauses Act of 1871, the candle power and pressures are now prescribed by special Acts which vary in different towns, and in most towns where the corporation or gas companies have special Acts the standard is higher than the above.

In columns two and three of the following Table are given the candle power and price of gas in January, 1877, in some of the principal cities and towns in the kingdom. The actual is usually one to three candles higher than the guaranteed power.

TABLE I.

Name of Town.	Guaranteed Candle Power.	Price of Gas per 1000 ft.	Price the Gas should be sold at to give the same economy as Glasgow Gas when properly burnt.	Price the Gas should be sold at to give the same economy as Newcastle Gas when properly burnt.
		s. *d.*	*s.* *d.*	*s.* *d.*
Glasgow. . .	25	4 2	——	4 10
Liverpool . .	20	4 0	3 4	3 10
Manchester .	20	3 4	3 4	3 10
Birmingham.	15	2 7½ to 3 1 net	2 6	2 10¾
Sheffield. . .	15	2 9 to 3 0	2 6	2 10¾
Bristol . . .	13½	3 3	2 3	2 7½
Leeds	16	3 3	2 8	3 1
Newcastle-on-Tyne	14	2 8½ net	2 4	——

The fourth column shows that, *when properly consumed,* Glasgow gas, although sold at the highest rate, is actually the cheapest gas when its lighting power is compared with that of the gas in other towns; and column five shows that Newcastle gas, which is sold at the lowest rate of any, is dearer, light for light, than either of the higher priced gases of Manchester or Glasgow, the gas in all cases being consumed in such a manner as to bring out something like its full lighting power. But as it is the exception and not the rule that gas is so burnt, the results given in columns four and five are not generally applicable, and judging from experience the 15 and 16 candle gases are the cheapest, all things considered, although their price is high, in proportion to their candle power, when compared with Glasgow gas at the prices here given.

12. *As gas of a high standard costs more per cubic foot than that of a lower standard, what advantage should there be in using the former?*

1st. It is seldom dearer for a given amount of light when both gases are *properly burnt*. For instance, if we require a light equal to 16 candles, the following are the quantities of gas of different standards required to give that light.

TABLE II.

Illuminating Power of Gas in Candles.	Cubic Feet of Gas required to give 16 Candles.	Illuminating Power of Gas in Candles.	Cubic Feet of Gas required to give 16 Candles.
12	6·8	22	3·6
13	6·1	23	3·5
14	5·7	24	3·3
15	5·4	25	3·2
16	5·0	26	3·1
17	4·7	27	2·9
18	4·4	28	2·8
19	4·2	29	2·7
20	4·0	30	2·6
21	3·8		

A glance at the fourth column of Table I. will suffice to show the economy of using good gas even at a high rate.

2nd. As 1000 feet of cannel gas will yield very little more carbonic acid and other products of combustion than 1000 feet of common gas, and as only about one half the quantity of gas should be required for a given amount of light, the air should be vitiated to only a little over one half the extent when cannel gas is used.

3rd. If there be any foundation for the prejudice against the use of gas on account of the alleged baneful effects of the sulphuric acid produced, there should be a great advantage in using cannel gas, as it usually contains only about one half the quantity of sulphur that is found in common gas, and when only one half the quantity of gas is required for a given amount of light, only one fourth the amount of sulphuric acid will be found.

13. *If the standard of illuminating power is sufficiently high in most towns, and the standard is maintained, why are there so many complaints about the light?*

Simply because the gas is often burnt in such a manner as to get the very smallest possible amount of light out of it. With ordinary burners, instead of getting 15 candle light from common gas, 5 or 6 candles is the rule. In Glasgow, where the gas is exceptionally good, 5 or 6 candles is the rule, instead of the 27 candles at which the gas is supplied, and instead of the 20 candles that can easily be obtained. The higher the quality of gas the greater will be the care required to burn it, so as to get all the light out of it without producing smoke. It may be said that at the same price

16 candle gas is preferable to 20 candle gas for ordinary purposes with the present state of knowledge found amongst gasfitters.

In some cases gas is abandoned altogether, and replaced by candles and oil lamps, because the simple rules for its proper burning have not been understood.

14. *Who is to blame for this?*

The ignorant gas-fitters on the one hand and the ignorant users on the other. If any one will observe the different qualities of light after dark in the various clubs, hotels, factories, theatres, churches, houses, &c., using the same gas, he cannot fail to be struck by the ignorance and want of observation of engineers, scientific men, doctors, lawyers, and clergymen, who might be expected to know something about such an extremely simple matter as gas-lighting. Whilst the rooms of one house are cheerfully, brilliantly, safely, and cheaply lighted in every corner, those in the next house often have a gloomy and depressing light at much greater expense.

15. *What is meant by the pressure?*

In order to make the gas flow in sufficient quantity through the most distant burners, the weight of the large gas-holders, or gasometers, at the works is utilised to force the gas through the pipes, and it issues from the burners at a "pressure" depending upon the distance travelled, obstructions in its path, height, compared with the gasworks, at which it issues, and other conditions.

16. *How is the pressure measured?*

By means of a "pressure gauge," which in its simplest form is a glass tube 7 or 8 inches long, bent in the form of a U, and half filled with water. One leg of the gauge is open to the atmosphere, and the other is connected to the pipe or burner nozzle, so that in opening the communication between the gauge and the gas in the pipe, the column of water in one leg is forced down, and that in the other forced up by the pressure of gas. The difference in the height of the two columns is the measure of the pressure of the gas, and is usually expressed in tenths of an inch. Suppose the water is depressed $\frac{3}{10}$ of an inch in one leg, it will be raised $\frac{3}{10}$ in the other, and the difference in height will be $\frac{6}{10}$, which is the pressure of the gas.

17. *What is the usual pressure at which gas is supplied?*

The pressure at the main varies very much at different times of the day, according to the demand and supply in different localities and at different heights.

According to the Gas Act of 1860, "all gas supplied by a company to a private customer shall (except in case of accident or repairs) be supplied at such pressure as to balance from midnight to sunset a column of water not less than six-tenths of an inch in height, and to balance from sunset to midnight a column of water not less than one inch in height at the main as near as may be to the junction therewith of the service-pipe supplying the customer's house, building, or lands. If a company fail in any case to comply with this section, they shall for each day on which they so fail be liable to a penalty not exceeding ten pounds."

18. *In which way do the diameter and length of pipe affect the pressure?*

Supposing there were no flow of gas in the pipes, that is, supposing there were no leakage, and all outlets were closed, then the pressure would be the same throughout the whole system of mains and services at the same elevation with respect to the gas works. But when the gas is being used at the burners it is flowing through the pipes, and the pressure at any point will then depend upon the area of free way in the pipes, taps, and valves through which the gas passes, compared with the aggregate area of the burners in use, modified to some extent by the number and shape of the bends, elbows, and length of pipe. With a given size of pipe and pressure at the meter, by increasing the number of burners and length of pipe sufficiently, a point may be reached where there is practically no pressure at all at the far end of the pipe. This circumstance is of great importance, as a considerable pressure may be indicated by the gauge when the gas is turned off at the burners, but which may be seriously diminished when the gas is lighted. Consequently, in testing the pressure at any point, regard must be had to the quantity of gas being used at the time.

19. *Cannot the pressure be estimated by the height of the flame from the socket with the burner removed?*

Yes; but the estimate is apt to be erroneous. In making this test in a room the flame can only be endured momentarily, unless the ceiling is protected from the smoke produced. And this momentary test may be very deceptive, for this reason:—when the pipes are full of gas and there is no consumption going on, the pressure at any of the burner taps will be equal to the pressure in the main, no matter what obstruction there may be, so long as there is any passage at all. On igniting a jet without a burner, the height of the flame will at first be that due to the pressure in the main. But it will depend upon the length, diameter, and bends of the pipe on the outlet side of any obstruction there may be, and the relation between the size of the passage past the obstruction, and the size of the passage where the flame is burnt, whether this height will be maintained. This can easily be demonstrated as follows. First ascertain the height of a single flame without a burner, then gradually close the tap at the meter until the flame is reduced considerably; now turn off the light, and after waiting two or three minutes, light the jet again, and it will be found to be of the same height as at first, but it will gradually diminish until it reaches the former reduced height, or that due to the reduced pressure in the pipe, consequent upon the flow of gas at the jet being greater than that through the partly closed tap at the meter. On lighting a second jet without a burner, the pressure and height will be still further reduced.

Starting with a meter tap partly closed

With 1 jet 11 inches high, the pressure was 5-10.
„ 2 „ 8 „ „ „ 2½-10.
„ 3 „ 6 „ „ „ 1-10.
„ 4 „ 3½ „ „ „ 1-20.

In a trial where a single jet, consuming four feet of gas an hour at $\frac{12}{10}$ pressure, was kept burning, the heights of flame at another jet without burner, and the corresponding pressures before and after turning on the jet, were found to be as follows :

PRESSURE.	HEIGHT OF FLAME.
12-10 and fell to 10-10	18 inches.
9-10 „ „ 7-10	15 „
6-10 „ „ 3-10	12 „
4-10 „ „ 2-10	9 „

The above results were found with sixteen candle gas and an ordinary $\frac{3}{8}''$ socket and tap.

20. *What effect has the elevation above or below the gas-works on the pressure?*

It is pretty generally known that the pressure of gas increases or diminishes as we ascend or descend. This is owing to the pressure of the atmosphere decreasing as we ascend. Where there is no flow of gas in a pipe that rises to a considerable elevation, the pressure of gas against the sides of the pipe is practically the same at all heights, being, however, greatest below by the amount due to the weight of the column of gas. But on opening a communication at any point between the gas and the atmosphere, the pressure increases approximately 1 inch for every 100 ft. of elevation, or $\frac{1}{10}$ of an inch for every 10 feet, so that in a house of six storeys, each 10 feet high, with a pressure of 1 inch at the basement, there will be an increase of $\frac{1}{10}$ of an inch for every storey as we ascend, until the pressure reaches $\frac{16}{10}$ inch at the top storey. This fact accounts for the low pressure sometimes found in the parts of towns lying below the level of the gas-works.

21. *Is not the pressure at the burner also influenced by the barometric condition of the atmosphere?*

No; because the pressure of the atmosphere on the gas-holder at the works increases or decreases as it does at the burner.

22. *Has the barometric pressure any effect upon the light?*

Yes; as the barometer falls the light diminishes, and, according to Dr. Frankland, at the rate of 5·1 per cent. for every inch of fall. According to Dr. Letheby, "In London, the difference in the value of the light when the barometer is 31 as compared with what it is at 28, is fully 25 per cent., and it may be as well that this difference is noteable." This no doubt accounts for many of the complaints of the "bad light" we have often in November, when the barometer is usually very low.

CHAPTER III.

ADVANTAGES OF USING GAS.

1. *Why is gas now almost universally preferred to all other kinds of lighting?*

Because, *when properly applied,* it is more convenient, cheaper, more cheerful, cleaner, safer, and, for an equal amount of light, less unwholesome than any other system of lighting.

2. *In which way is gas more convenient than any other kind of light?*

When properly applied, gas can be taken to any part of any room in a house, and, when not turned off at the meter (see p. 49), is always ready for lighting from year's end to year's end, by simply turning the tap and applying a light. The light can be diminished or increased at a moment's notice by simply turning a tap, a matter of great importance in many places. There is no oil lamp to be replenished at intervals, or candles to be replaced, probably more than once at a long sitting. It can be taken by means of a gasalier from the ceiling, or by a gas bracket from the wall at any part of a room, and be always out of harm's reach, and by aid of a flexible tube, a gas light can be moved about and placed as well as a candle or oil lamp in any corner of a room at will. The light can be extinguished without soiling the fingers, or causing the unpleasant smell which so often attends the extinguishing of candles and oil lamps.

3. *How much cheaper than candles or oil is gas?*

Theoretically, this is easily reckoned if we know the comparative prices. Taking 15 candle gas at 3*s.* 4*d.* per 1000 feet, we have 25 feet at the cost of one penny, or one pennyworth of gas, when properly burnt in a room, will give the light of about 12 sperm candles for 5 hours. This is, of course, assuming an equal amount of light in each case, but when candles are used a very dim light is considered sufficient in most cases, and the saving in lighting a house with gas over lighting one with candles is not so great as most writers on gas-lighting assume. It is only when we take into account the increased cheerfulness that the great difference in value received becomes apparent. Gas is generally used very extravagantly. Theoretically speaking, 1000 feet of 15 candle gas will give as much light as 57 lbs. of best mould or dip candles; or 51 lbs. of wax candles; or 53 lbs. of composites; or 6 gallons of sperm oil. Practically speaking, when compared with wax and composite candles, placed on a table, at least 50 per cent. of the standard candle power of the gas should be deducted to allow for the loss by burners and globes, and height from table.

4. *Can it be maintained that it is less unhealthy to use gas than candles or oil?*

Light for light no doubt it is less unhealthy. The following table by Mr. L. Thompson shows that a person can exist in a confined room lighted with gas longer than in one equally lighted with tallow or wax candles, oil, &c. In these experiments a standard light by the various combustibles was burnt in a given quantity of air, and the time required by each light to extinguish itself noted :—

Rape or Colza Oil	was	extinguished in	71	minutes.
Olive Oil	,,	,,	72	,,
Russian Tallow	,,	,,	75	,,
Town Tallow	,,	,,	76	,,
Sperm Oil	,,	,,	76	,,
Stearic Acid	,,	,,	77	,,
Wax Candles	,,	,,	79	,,
Spermaceti Candles	,,	,,	83	,,
Common Coal Gas	,,	,,	98	,,
Cannel Coal Gas	,,	,,	152	,,

No doubt these results are correct enough, but they are laboratory experiments, and when we apply the quantities to actual practice they show that gas, as burnt in the usual extravagant manner, is more injurious than any of the other systems of lighting.

5. *Is it not a fact that many people will not have gas in their houses on account of its real or imagined unwholesomeness?*

Yes; and there can be no doubt, as generally used, there is an oppressiveness in a room lighted with gas not felt in a similar room lighted with candles, but the reason is not far to seek. It is too often forgotten in comparing the effects of gas with those of oil or candles, that in using gas its very cheapness leads to its abuse, and an immense quantity is wasted; moreover, if our rooms with the usual want of ventilation were lighted to anything like the same degree by oil or candles that we usually find when gas is used, we should simply not be able to live in them for smoke, dirt, smell, heat, and vitiated air.

6. *What should be done in order to overcome or prevent the unwholesome effects attending the burning of large quantities of gas?*

Rooms should be properly ventilated, and in such a manner that the warm residue of air, carbonic acid, aqueous vapour, and sulphuric acid resulting from combustion can pass away at or near the ceiling before they descend in cooling and vitiate the atmosphere in the room.

7. *But is this not a matter for the architect to see to?*

Yes; but it is as a rule overlooked, and so long as architects pay so little attention to ventilating sitting rooms, it cannot be expected they will learn much about the lighting of these rooms. There is no more attempt to ventilate rooms now, when burning large quantities of gas, than there was a hundred years ago, when the products of combustion from the means of lighting were only a small fraction of what they now are when gas is used.

8. *Is not the presence of sulphur in gas very injurious to health?*

In spite of what many authorities have said about the great injury caused by the production of sulphurous acid in burning gas, it is questionable whether the very small quantity of sulphur present in the gas of any of our large towns is capable of doing injury to persons in the rooms where the gas is burnt. There can, however, be no doubt that the sulphuric acid (oil of vitriol) produced by the oxydising of the sulphur in the moist atmosphere wherever gas is burnt night after night and year after year, if allowed to accumulate, becomes in time very injurious to leather, metal-work, cotton goods, &c., in spite of what many eminent chemists have asserted to the contrary. Take for instance the following statement made by Dr. Odling in 1868:—

"I am altogether at issue with the public when they maintain that the sulphur of gas produces, by its combustion, oil of vitriol, or that the amount of sulphur ordinarily contained in gas is of any consequence whatever; and a little consideration will, I think, satisfy you of the soundness of this position. We will assume that coal gas contains, not 20, but 40 grains of sulphur in 100 feet, a quantity at any rate greatly exceeding the reality. Now, making another extravagant assumption, that the whole of these 40 grains of sulphur would be completely burnt,—and, in reality, they would be burnt very incompletely—they would furnish, by their combustion, 80 grains of sulphurous acid gas. This quantity of the produced sulphurous acid would occupy at ordinary temperatures about $\frac{1}{15}$th part of a cubic foot; and since 100 cubic feet of our coal gas give $\frac{1}{15}$th of a cubic foot of sulphurous acid, 1500 cubic feet of coal gas would be required to furnish one cubic foot of the acid, even upon the extravagant assumptions we have purposely made. But the combustion of 1500 feet of coal gas would produce something beside sulphurous acid. It would produce at least 1000 cubic feet of carbonic acid, and in addition to its dilution by other gases and vapours, we should have our sulphurous acid diluted by 1000 times its volume of carbonic acid. Now, if we can get at the proportion of carbonic acid in the atmosphere of a room highly illuminated with gas, and take the 1000th part of that proportion, we shall be able to form some notion of the amount of sulphurous acid present. You will remember that the amount of carbonic acid furnished by the breath of one individual is equal to that furnished by two 3-feet gas burners, and that a maximum amount of carbonic acid found in the atmosphere of a crowded theatre was 0·32 per cent. Now, if in addition to our previous unreasonable supposition, we farther suppose that an atmosphere contains

0·2 per cent. of carbonic acid furnished by gas combustion, you will see that the whole matter becomes a *reductio ad absurdum* that we might have one-half millionth part of sulphurous acid present in the air of a gas-lighted room."

9. *If the above statement is not correct, why is it reproduced here?*

Because it is so often quoted in evidence of the harmlessness of burning gas in a room, and also in order to correct the two fallacies it contains, viz. :—1st. Oil of vitriol *is* formed when ordinary coal gas is burnt, and seeing that the sulphur is oxydised in the presence of the aqueous vapour produced by combustion, it is strange that its formation could be denied; and 2nd. It avails not to argue that the quantity of sulphur compounds produced at one burning is infinitesimally small, for if this quantity be not removed, and it becomes deposited on articles in the room, it is only a question of time and number of repetitions for the insignificant quantities to become very formidable collectively.

10. *If not to the sulphur impurities, to what, then, is the unhealthiness due?*

To the quantity of carbonic acid and aqueous vapour produced by combustion not being carried away by proper ventilation. With the products of combustion cooled down to something like the average temperature of the atmosphere in a room, every foot of common gas burnt yields about $\frac{6}{10}$ths of a foot of carbonic acid, and about $1\frac{1}{3}$ feet of aqueous vapour; consumes about $1\frac{1}{4}$ feet of oxygen and sets free about 5 feet of nitrogen, that is, destroys $6\frac{1}{4}$ feet of air. The carbonic acid is the most dangerous, as it is a poisonous gas, and produces a drowsy feeling when present in considerable quantity;

but it is the aqueous vapour which usually causes oppressiveness, itching of the head and skin, and irritability. In a badly ventilated room where gas is burnt, the air becomes saturated with moisture, which checks the insensible perspiration, and produces the unpleasant feeling so often complained of. Ventilation alone can obviate this evil. That the irritation and unpleasant feeling produced is not due to poisoning by inhaling sulphurous acid or carbonic acid, is proved by the instantaneous relief felt on stepping into the fresh air.

11. *Can the unpleasant smell of gas, so often accompanying its use in houses, be avoided?*

Certainly, by preventing its escape unburnt. But instead of being an objection to its use, the smell should rather be considered as one of the greatest advantages in using gas, as it at once gives warning thereby of waste, poisoning the atmosphere, and danger from explosion. We may at once divide the smell into two kinds. 1st, that arising from leakage of gas from pipes and joints under the floor or in the gas-fittings. 2nd, that given off by the unconsumed gas, which is a consequence of the use of bad burners or burners badly applied, and of attempting to burn the gas at too high a pressure.

Now the first may be avoided altogether in new buildings, where the gas is not laid on, by employing experienced gas-fitters, and by insisting on the absence of smell being guaranteed by the contractor for the gas-fittings. In taking an old house, where the pipes are already laid, all the occupier has to do is to order the gas-fitter to fix a pressure gauge at one outlet and plug all the others. Then have the gas at the meter turned full on at dusk, when the highest pressure in the main will be indicated by the gauge, now turn off the tap at the meter, and observe by the gauge how long the pressure is maintained. *The escape hole in gauge must of course be plugged for this test.*

In the event of the gauge dropping suddenly and indicating leakage of gas, the plugs and all the joints, bends, and fastenings should be examined, as well as the whole length of piping, till the defect where leakage occurs is discovered and made good. After the fittings are attached a similar test should be made, and if the gauge shows no indications of leakage, it may be assumed that everything is right, and any smell subsequently discovered may be set down to defective taps or burners, or an insufficient supply of water at the gasaliers, which can easily be remedied.

As to the second cause of smelling, viz., gas passing off unconsumed through the flame. It is doubtful whether this really occurs, but many experienced people maintain this will always take place more or less at high pressures, say $\frac{10}{10}$ths and upwards, with any of the fish-tail or union burners commonly used and applied by the general run of gas-fitters, whether these burners are styled improved or patent, and whether they are simply of iron or made with enamel, lava, steatite, or adamas tops, and which do not contain a proper provision for effectually reducing the pressure a short distance from the point of ignition. These are all worthless for domestic use, however well they may be adapted for special cases, but in dwelling houses they should never be used where health, comfort, and economy, are sought.

12. *Is not a smell sometimes perceived when the taps in the gasalier are opened, and when the burners are tight and do not let the gas pass unconsumed, and the gasalier is not pulled down too far?*

Yes; sometimes this happens, and is caused by the gas finding its way through the miserably thin metal of which too many of these gasalier branches are made. The leakage is often so slight as not to be traceable by applying a light, and is not perceived till the gas has been lighted a considerable time. The length of time will depend upon the pressure of gas, and in some cases is only noticed when the pressure is unusually high. The smell arising from defective fittings, in such cases, is usually ascribed to the bad quality of the gas, and of course without reason. By reducing the pressure at the meter this leakage can often be prevented, but if not, new branches should be obtained. In one case a coating of lacquer was attended with success, but this was only temporary.

13. *Many people object to the singing and roaring noise which often accompanies the use of gas. Is this noise a necessary evil?*

By no means. There are three kinds of noises which are due to different causes. One is the loud and shrill singing often heard in using common burners, especially union jet or fish-tails of small size. This is caused by the pressure being too great at the outlet, and inducing a current of air sufficiently strong to penetrate to the core of the flame, forming an explosive compound, and the rapid repetition of the slight explosions cause the whistling noise. This is readily proved, when there is sufficient pressure, by partially closing the tap near the burner, when the noise can be produced or stopped at will by opening and closing the tap. The best remedy for this is to reduce the pressure at the meter by partially closing the tap there, and have larger burners applied, which will give a whiter and better light, and effect a saving of gas. Should, however, the tap at the meter be subsequently opened fully, and not turned off again, ordinary burners of large size will cause a great waste of gas, whence "Brönner's," or other check burners should be used (see p. 65 for further information on this point), the second noise is the feeble whistling sometimes heard, and is caused by the vibration of the union burner, when too strong a current of gas is blowing through the orifices.

14. *Are there not noises that cannot be prevented by reducing the pressure at or near the burner, say to* $\frac{4}{10}$*ths?*

Yes; these are due to the other cause above alluded to. Sometimes the noise is a dull roar, at other times a hissing sound. In many such cases the roaring is only heard when the tap is half closed, and ceases when the tap is turned full on, which shows at once it is not due to excessive pressure. When this happens it is best to remove the burners altogether, and ascertain whether the noise still continues at any particular position of the tap, the gas not being lighted. It will generally be found that the noise occurs when the tap is three-quarters open, and in one direction only, if on a straight pipe, or when close to a bend it may occur with the tap full open. It is caused by the gas at a sufficiently high pressure impinging against the side of the thin pipe of the gasalier or bracket. What is required to prevent this noise is to so guide or distribute the current of gas passing through the way in the tap as not to allow it to impinge forcibly on the thin metal in such a manner as to cause the noise. This may be done by inserting a very small quantity of cotton wool in the tap way—and in such a manner that it will not be carried away by the current of gas; a quantity just barely sufficient to obscure, but not prevent, the light passing through, will generally be effective. Slightly countersinking the ends of the way through the tap has sometimes remedied this evil. The burners are always blamed for this noise, but they have nothing to do with it, and it can easily be decided, if the question arises, by trying whether the noise still continues when the burners are removed altogether.

15. *How can it be maintained that gas is safer than other modes of lighting?*

Notwithstanding the much greater amount of light produced from gas than from candles in our towns, there are only about one half the number of fires caused by gas. If we take lodgings and dwelling houses, there are about ten times as many accidents from candles as from gas, and if we take into consideration the much greater quantity of light enjoyed by the use of gas, the proportion of accidents is very much greater, still, in favour of gas.

16. *But is not gas liable to explode?*

Yes; when mixed with air it forms a very dangerous explosive compound, but the accidents from explosions are few compared with the accidents from explosions of the numerous mineral oils and spirits used for lamps. The small quantity of spirits allowed by the State to be stored in one place and other restrictions upon their use appears to be a proof that they are more dangerous to handle than gas.

Explosions from gas are usually the result of glaring stupidity or recklessness. A warning that the presence of a light is dangerous is always given by the strong smell which accompanies an escape of gas. Whenever an escape is discovered by the smell, the gas should be turned off at the meter, and the place, whether a room, cupboard, or underneath the floor, should be properly ventilated before a light is brought near. When the smell has passed away, the gas may be turned on again, and an attempt made to discover the position of the leakage without a light. After covering the defective place with white lead, clay, or sacking, according to the nature of the defect, and its position, the gas may be turned on and a light brought near so long as no smell is perceived.

CHAPTER IV.

ON GAS-FITTERS AND OTHERS.

1. *After showing in the last chapter that gas possesses such great advantages over all other kinds of lighting, why is there so much grumbling at the high gas bills, and bad gas-light in every town in the kingdom?*

Simply because, in nine cases out of ten, the gas is not properly applied and used. In ninety-nine per cent. of the complaints about "*bad gas,*" the cause is simply due to the ignorant and stupid way in which the gas is laid on to the house and burnt.

2. *Can it be maintained that gas-fitters, as a rule, are not fit to be trusted with the lighting of a house or building?*

Decidedly, they are not. Although capable of "blowing a joint," and applying white lead and common burners put into their hands, they are not to be entrusted either with determining the size, course and arrangement of pipes, brackets, and gasaliers, or in determining the description and sizes of burner for the different rooms, passages, &c., in a building.

Pipes are, as a rule, laid in without any regard to the number of burners, length of pipe, pressure at command, or quality of gas. The same sized pipes are put in whether the building be 200 feet above the gas-works or 100 feet below. The same remark applies to meters.

Because a three-light meter is found sufficient to supply gas for 10 lights in a house where there is a great pressure, it is assumed the same result will be obtained in another case where the pressure is only a fraction of the other. Then with regard to burners, Nos. 2, 3, and 4 burners are carelessly used without any regard to the quantity of light required or pressure available in various parts of a building. In fact, all common sense engineering rules are ignored.

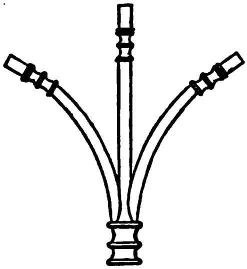
3. *Give instances of the ignorance or carelessness of gas-fitters?*

1st. As a rule they apply the same size of burner to every room and part of a house—No. 3 being that most in vogue—without regard to pressure and amount of light required in rooms, passages, closets, etc.

2nd. Burners are seen in shop windows all over the kingdom, arranged horizontally instead of being fixed upright. This is done with a view to avoid casting a shadow, and to throw more light below. But the effect is the reverse of what is intended. Unless there be about an inch pressure or more, a horizontal flame flickers and smokes very much, and gives a very unsatisfactory light, and with a pressure high enough to keep the flame steady, the light is very far below that which the gas is capable of yielding with a vertical flame and lower pressure, unless the burner is a very bad one indeed. It is only in the case of sunlights and a few exceptional cases that the use of a horizontal flame can be justified.

3rd. Shops, rooms and offices, are often found provided with lights arranged in clusters. A very favourite arrangement of gas-fitters is the three-light, as shown in fig. 1, with small—2, 3, or 4—fishtail or tulip burners. One large slit burner will give a much better light, and where there is a good pressure, a Brönner burner can be applied to give a better light with half the consumption of gas. It is only in draughty and exposed situations that the use of a cluster can be justified. If the cluster is used to please the eye, then, of course, being a matter of taste, argument about it is useless.

Fig. 1.



4th. Cases occur every day where gas users complain of defective lights, and the gas-fitter recommends larger pipes to get more pressure, and applies smaller burners to keep down the consumption. This, too often, is just the reverse of what should be done, and the light, instead of being better, is worse than before. The gas-fitter, however, easily gets over the difficulty, by raising the cry of bad gas, and adducing as evidence the smell he has assisted in causing. Now "bad gas" is just one of these cries that everybody is ready to join in, and the gas-fitter's bill is paid without a murmur.

One case in point may be mentioned in illustration of this:—The mayor of a large town, who was also chairman of the gas committee, having to entertain some distinguished guests, had a new meter and service pipes of very large size laid into his house, in order to have a "good pressure" for over 100 lights all burning at one time. The first result was a breakage of very costly globes on the gasaliers. In order to avoid this, the gas-fitter put on very small "Bray's" burners. The result then was a very dismal, bluish light. As usual, the quality of the gas was blamed. In spite of the user being chairman of the gas committee, he had a badly lighted house, and joined in the cry against the engineer of the gas-works. Carburetters had been tried, but, being too troublesome to manage, were given up. At last the owner consented to make a trial of Brönner's burners. With a saving of one-third in the consumption of gas, he obtained such a blaze of light in his house that he at first thought some trick had been played him, but was soon convinced he had previously been badly advised by the gas-fitter.

5th. Another instance of ignorance is the great and unnecessary expense gas-fitters put their customers to, in recommending a number of small lights for rooms, shops, etc., where half the number of larger lights would not only be far more efficient, but also less unhealthy and more economical.

6th. Gas-fitters as a rule apply the same burners to common gas that they use for cannel gas, and *vice versâ.*

7th. The indiscriminate use of sharp elbows, instead of easy bends in the arrangement of piping, and which in time usually leads to great annoyance, is another instance of the careless manner in which gas-fitters do their work.

8th. A great number of the gas explosions that have occurred have been caused by gas-fitters approaching the place where there is a smell of gas with a light.

9th. When called in to cure the evil of bad pressure, they usually omit to take out the burners, taps, and bracket joints, to remove the white lead and tallow, with which they have choked up the passage for the gas.

10th. They urge the consumers to cry "bad gas" when, through the gas-fitter's ignorance, they have failed to obtain a good light in a building.

11th. They often erroneously estimate the pressure by a momentary inspection of the height of a flame with the burner removed (see p. 18).

4. *What mistakes do gas-fitters often make in laying pipes?*

They do not give the pipes sufficient downward inclination towards the meter to ensure the water finding its way there, or towards the taps, plugs, or caps rendered necessary by the arrangement of the pipes. Sometimes these taps and plugs are omitted altogether, when the gas-fitter has been in the habit of laying his pipes from dry meters, and loses sight of their importance in dealing with a wet meter. A very common fault in laying lead pipes is for the gas-fitter, in bending the large pipes on both sides of the meter and the smaller pipes inside the building, to nearly choke up the area of the pipe by careless workmanship, and in fixing lead branch pipes to put them in such a position as to be liable to be squeezed flat and rendered useless.

5. *But is the gas-fitter always the only one to blame when the lighting is defective with an adequate supply of good gas in the main?*

By no means, for very often he is so screwed down in his contract by the architect or owner, that when the sizes of pipes and other details are not specified, he has either to put in too small piping and scamp the work, or lose by the contract; and grand mansions on which thousands have been ungrudgingly spent on style, decorations and fittings, are very badly lighted in consequence.

6. *Should not the architect be responsible for the lighting of a building?*

As it is almost as barbarous to design a house without means for carrying off the air vitiated by the gas used for lighting, as it would be to provide fireplaces without chimneys, it appears reasonable that the architect should have the direction of the lighting, as he has of the ventilation, the amount of which in large buildings is (or should be, in some measure at least) decided by the nature and amount of the lighting required. But as ventilation is often ignored altogether in designing new houses, but little is to be expected from the architect in the way of improving the system of lighting by gas. Houses of all sizes are still built with no better means of ventilation, than was the rule 100 years ago, although now the rooms are flooded with light so that persons may be able to read in the farthest corners of the room, whereas formerly two or three candles were deemed sufficient.

7. *Who else is to blame for bad light, high gas bills, and poisoning the air unnecessarily?*

Whoever designs and makes those atrocious gasaliers and globes that the gas user so calmly chooses and pays for.

8. *What defects in the gasaliers are alluded to?*

1st. The flimsy material of which some are made in the arms, and which allows the gas at high pressure to escape into the room, but in such a small quantity that the source of leakage cannot readily be detected, although the smell renders it certain that there is an escape of gas somewhere.

2nd. Those absurd supports for the globes which appear to be contrived to prevent as much light being shed downwards as possible, where it is most needed. These supports are sometimes a large disc 4½ inches in diameter screwed on to the burner socket. This is the very worst shape the support can possibly be. It should be made so as to throw as little shadow as possible. When these absurd supports are used they throw a shadow over the whole table beneath them. *One* light with a properly made triangle to support a good globe will often give a better light on a table than *five* lights with these globe supports, or galleries as they are called, often used. See page 72 for further information on gasaliers.

3rd. The globes are often so opaque that more than half the light is absorbed, whence twice the quantity of gas has to be burnt to get what, after all, is only an indifferent light.

It is no exaggeration to say that the use of badly designed gasaliers and obscure globes is the cause of half the consumption in some houses, and as these gasaliers are as a rule fitted with bad burners, the evil is still further increased.

9. *What is the most remarkable circumstance connected with the designing of gasaliers?*

That no one appears to consider that a single light is ever sufficient for any place but a kitchen or hall. This is the only conclusion that can be arrived at when it is so difficult to find a single-light pendant fit to place in a fashionably appointed sitting-room.

10. *Who else is to blame for bad lights?*

The owner of the house, or whoever chooses those dark colours with which the walls, and even the ceiling, are often either papered or painted. No light is pleasant unless diffused, and for this it requires to be reflected from a large surface overhead as well as from all sides.

11. *Is there any other class of people to blame for the bad lighting found all over the country?*

Yes, those swindlers and unscrupulous people who make their appearance every autumn, each with a stock of worthless burners, which they palm off upon the public with an equally worthless verbal guarantee. After trying a few of these men's burners, the gas user generally makes up his mind to have nothing more to do with improvements of any kind, and becomes contented with his bad light.

CHAPTER V.

THE METER.

For Figures, see Plate III. at end of book.

1. *For what purpose is the meter used?*

For measuring and registering the quantity of gas supplied to the consumer, whether it be burnt or lost by leakage.

2. *How does it do this?*

By recording at the index or dial the number of cubic feet of gas which pass through the meter to the burners or other outlets.

3. *Is there any difficulty in reading and understanding this index?*

Not to anyone who can tell the time by a watch.

4. *Explain the index.*

There is some slight difference in the arrangement of the indexes on meters of different sizes, and by different makers. The annexed cuts are examples of those in common use. In fig. 2, neglecting the small circle above for the present, we see there are three indexes marked respectively 100,000, 10,000, and 1000, which denote the number of cubic feet recorded by one complete revolution of the hand on each index. The hand moves in the same direction as the figures count; that of the first, *beginning at the right,* from left to right, like the hands of a watch; that of the second from right to left; and that of the third from left to right.

In a new meter, before any gas has been used, all the hands point to zero (0). On commencing to use the meter, the hand of the right index will be seen to move first. When it arrives at 1 it shows that 100 feet of gas have been used, when it points to 5 it shows that 500 feet have been used, and so on till it gets to 0 again, when it indicates that 1000 cubic feet of gas have passed through the meter. At this stage, the hand of the second index will have reached 1, every figure on this index indicating a complete revolution of the hand of the index to the right, or a consumption of 1000 feet. Again, when the hand of the middle index shall have made one complete revolution and arrived at 0, it shows that 10,000 feet have passed through the meter, and at this stage the hand on the index to the left will have reached 1, every figure on this index indicating 10,000. Now taking the position of the hands in fig. 2, it is evident that it reads 70,000, 6000, 100, or 76,100 feet of gas as having passed through, say on July 1st. Now suppose after six months, or on the 1st of January, the reading of the meter stands as in fig. 3, at 88,200, we have by subtracting the former from the latter.

Consumption on Jan. 1st, 88,200
,, July 1st, 76,100
12,100 cubic feet of gas consumed in six months.

At 4*s.* per thousand feet we should have 12,000 feet = £2 8*s.*; and 100 feet, say at 5*d.* per 100, we should have a total of 12,100 feet at 4*s.* = £2 8*s.* 5*d.*

5. *Is there any caution required to avoid mistakes?*

Yes; be sure to take the figure on the index which the hand has passed, and not the figure which it is approaching. If there be any question about this, when the hand is very near or just over the figure, it can be decided at once by referring to the index to the right, the hand of which will be between 0 and 1, if the figure in question has been passed, and between 9 and 0 if not yet reached.

6. *Is there any other caution required?*

Yes; don't forget that the middle hand goes from right to left, and not in the same direction as the hands of a watch.

7. *What is the use of the small hand and index above?*

This small hand is not noticed by the gas companies or their servants, but is very useful for experimental purposes. Referring to figs. 2 and 3, the small index is seen to be divided into quarter feet. The hand moves from right to left, and each revolution indicates 2 feet.

8. *For what particular purpose is this small dial useful?*

Any leakage from the pipes or fittings may be detected by it, by noting the position of the hand at long intervals, for instance, at night when the gas is all turned off in the house, and again next morning, or before the gas is lighted in the evening.

9. *For what other purpose is this small dial useful?*

For testing the consumption going on at any time with one or more burners in use, from which the amount of gas consumed, say, in a quarter of an hour in various parts of the building can be ascertained, and hence the consumption in an hour with the same pressure and number of burners can be decided.

10. *Give another example of its use?*

It is very useful for ascertaining the comparative efficiency of different kinds of burners in trials of quarter of an hour or longer. This small index is often divided into single feet, a revolution indicating 5 feet. Sometimes it is arranged vertically, and divided into 5 feet spaces, a complete revolution indicating 25 feet, see fig. 4. In larger meters, the vertical index is graduated for feet and 20 feet, each revolution indicating a consumption of 100 feet, as in fig. 5. Fig. 4 represents another marking of meter dial often met with. The cents indicate that the lowest quantity are hundreds. "Units" indicate that each figure represents a hundred, and hence a complete revolution represents 1000. "Tens" indicate that each figure represents 1000, hence a complete revolution represents 10,000, and so on.

11. *Why is it necessary to be able to read your own meter?*

In some towns the gas companies' quarterly account merely states the quantity of gas consumed, with the price per 1000 feet, and the amount due from the consumer, but does not give the position of the hands or reading of the meter at the beginning and end of the quarter, for which payment is due, unless this is asked for by the consumer with a view to check the consumption, which he can only do by being able to read the meter. The practice of not keeping a record of the consumption on the premises has led to great carelessness or worse on the part of the companies' servants.

12. *Give an example of this abuse.*

The following is selected from amongst a number of almost incredible instances told by the consumers. In a large manufacturing town, the owner of an extensive warehouse formerly had his place lighted with gas, but in consequence of a dispute with the gas company had the gas shut off at the main. To his surprise the gas account was rendered the following quarter as usual, and for about the same amount as had hitherto been the rule. On remonstrating with the gas company about the absurdity of the charge, they asked him to pay what he considered fair. Had this consumer been able to read his own meter he would have been able to check the quarterly account regularly, and would not have run the risk of being imposed upon. In this case the gas company had erroneously assumed the meter had been passing gas without registering, and acted accordingly.

Many gas users in our large towns are under the impression that they are charged arbitrarily, that is, overcharged, by the gas companies. This impression would no longer exist if they would learn to read their own meters.

13. *But do the meters always record correctly the amount of gas that has passed through?*

Not by any means, but if there is any reason to suspect the accuracy of a meter, it can be tested at a trifling expense by sending it to be stamped.

14. *Is there no simple means of testing a meter by actually measuring the quantity of gas it passes, and comparing this with the quantity indicated?*

Yes; but as some skill in manipulating the simple apparatus and considerable patience is necessary, the following methods can only be recommended to those who are fond of making experiments. Obtain a large jar, of glass if possible, of which the exact cubic contents in feet and in inches is easily calculated. As there are 6¼ gallons or 25 quarts in a cubic foot, a gallon jar filled 25 times, or a quart jar filled 100 times, will represent 4 cubic feet. Fill the jar with water, and cover it with a flat plate of glass or other material. It can now easily be reversed without spilling its contents and placed mouth downwards in a flat pan or trough containing two or three cubic inches of water. So placed the atmospheric pressure will keep the water in the jar. Having unscrewed and severed the connection between the house supply pipe and the meter, attach a piece of india rubber pipe to the meter, having a stop tap at the other end with an elbow to it. Turn on the gas till this pipe is filled, and note the position of the small hand or small index on meter. Carefully place the pipe under the jar without allowing the water to escape, and turn on the gas, which will bubble up and displace the water. As soon as all the water is forced out and the jar is full of gas, turn off the gas at the tap. Repeat the experiment again and again until the number of fillings multiplied by the contents of the jar, equal say 4 or 8 feet of gas. On comparing this with the consumption indicated on the meter, its accuracy or otherwise will be seen. It is advisable to allow a slight margin in favour of the meter index, to compensate for any inaccuracy on the part of the tester.

Another and simpler mode of testing a meter is to use a cask or other water-tight vessel, having a capacity of several feet, which can be accurately ascertained by measuring or weighing the water required to fill the vessel. The outlet pipe from the meter being connected with the top of the vessel when filled with water, and the gas being allowed to enter the vessel as the water flows out at the bottom, at the moment the water ceases to flow the vessel will be filled with gas, the amount of which being known can be compared with the quantity registered during the test by the meter.

15. *What precautions should be used in making such a test?*

It should be done in daylight, and no naked light should be allowed near the meter. As a rule, whenever any of the meter connections are removed, or there is an escape of gas, never approach the meter with a naked light, until all smell of gas has ceased. Every care should also be taken not to allow air to enter the meter through the outlet pipe, lest it should form an explosive compound with the gas in the meter.

16. *In case of the meter indication being found inaccurate, what should be done?*

The Gas Company should be applied to to have it rectified.

17. *What are the usual causes of error with a* WET *meter?*

The meter having either too little or too much water. These defects also cause the lights to "bob" up and down.

18. *How is the quantity of water regulated?*

On the top of the meter, to the right, will be found a nut which can be unscrewed for the purpose of admitting water. On the side, or front, of the meter, just below is another nut which covers the "vent." Take off these nuts and fill in water above till it just commences to escape by the vent. The meter is now properly charged. Any excess of water can be drawn off by the companies' servants from the well below on removing the screw there attached.

19. *What effect has too little water?*

Too little water tells against the gas company, consequently the meter is provided with a float to stop the passage of gas altogether when there is too little water.

20. *What effect has too much water?*

Too much water tells against the consumer, as the meter may make the same number of revolutions without passing the right quantity of gas. The revolutions are recorded on the dial, each revolution being measured at so much according to the size of the meter.

21. *Is there not a possibility of the wet meter ceasing to act altogether during a frost?*

Yes, but the freezing of the water can be prevented by adding a little glycerine.

22. *To what other defects is the wet meter liable?*

Sometimes the water becomes, in course of time, thickened by the tar and other impurities from the main. This causes a sluggish action of the meter, and consequently a falling off in the lighting of the building, although the pressure of gas at the main may be as good as before.

23. *What advantages has the dry meter over the wet meter?*

1st. As it requires no water for its action, there is no possibility of the passage of gas becoming stopped by frost. 2nd. There is far less risk of the lighting being rendered defective or annoying by the presence of water in the pipes. 3rd. There are fewer visits from gas-fitters' and gas companies' servants. 4th. The fewer visits are not attended by the offensive smell which always accompanies the re-filling or drawing off of the water from the meter. 5th. There is no risk of the gas supply being suddenly stopped through an insufficiency of water.

24. *Then why are dry meters not always used?*

Because until recently there has been a strong prejudice on the part of the gas companies against their use. It was considered that they were too delicate to answer well or last long, that they could not be easily tested, and that, as a rule, they told against the gas company, that is, they registered less than the actual quantity of gas that passed through them. The prejudice is now rapidly dying out, and as the stocks of wet meters held by the gas companies disappear, they are being largely replaced by dry meters.

25. *Is the dry meter as trustworthy as the wet meter?*

No; it is too delicate in its construction, and as the flexible leather inside is liable to stiffen in course of time, the dry meter cannot be depended on to register accurately for more than from two to five years. Hence it is considered necessary by gas companies to re-test the dry meters every few years.

26. *Is it not usually considered advisable on the score of safety to turn off the gas at the meter every night, or when the lights are not required?*

With a view to avoid slight waste or annoyance from leakage, it is advisable to turn the gas off at the meter, but certainly not with a view to greater safety, except in the event of fire.

27. *Why is it not safe as a rule to turn the gas off at the meter?*

Because next night, when the gas is wanted, perhaps in a distant part of the house, some one gets a light and turns on the tap at the burner. Finding no gas, the person runs off to the meter, forgetting to turn off the tap again which he has just turned on. On the way back, his attention is drawn away from the fact that the gas is escaping from the tap, and after gossiping or stopping to do something else on the way, and allowing time for the room to become filled with an explosive mixture of gas and air, he, or some one else, rushes in with a light, and an explosion, more or less serious, follows.

28. *In well-conducted establishments, where the above is not likely to happen, and it is considered advisable in the event of fire, etc., to turn off the gas at the meter what precaution should be observed?*

All the lights should be turned out first, in order that the pipes may remain full of gas, and be ready for lighting again next night, without having to wait till all the air is forced out of the pipes. This delay and annoyance occur when the tap at the meter is first turned off and the gas in the pipes is allowed to "burn itself" out, as it is commonly expressed. When the taps at the burners left on are at different levels, the air naturally enters the lower one and drives out all the gas before it at the highest burner, and so the pipes become full of air, which should be avoided as we have just advised. Should there be only one light left to burn itself out, and the tap be not turned off as soon as the light disappears, the air will still find its way through this burner, displacing the gas, and the same trouble may occur. This practice of leaving the light to burn itself out is unsafe, inasmuch as it may be forgotten that the burner tap is not turned off when the tap at the main is turned on next night; it is also dangerous in this way:—if the tap that is left turned on is not at the top of the house, the air entering when the pressure is gone, may form an explosive mixture with the gas in the pipe, and should it be attempted to light it at a large burner with the pressure off, the light may pass through the burner and cause an explosion. When the pipes are found full of air next night, after acting as above recommended, it shows that there is an escape of gas which should be seen to.

29. *What other precaution should be observed when it is the practice to turn off the gas at the service pipe?*

That the attendant, whose duty it is to see to the gas supply, should know when the tap is actually turned off and on. Many accidents have occurred through a misconception on this point, where the handles are not secured to the tap, and get accidentally put on at the wrong angle, so that the attendant, being in the habit of turning the handle *across* the pipe to turn off the gas, actually turns it on, not being aware of the change in position. The handle should either be secured or made to go on and fit at a particular angle only, or the attendant should be instructed to make sure that the tap is shut by feeling or seeing that the nick in the square on the tap is across the pipe or otherwise as the case may be.

CHAPTER VI.

GAS-PIPES.*

1. *What is the first point to determine in laying gas into a house?*

The diameter and material of pipes to be used.

2. *Do not the gas companies' servants lay on the service pipes?*

Yes, that is the pipe from the street main to the main cock within the building.

3. *Is this pipe always sufficiently large?*

In old buildings the service pipes are often too small and still oftener obstructed by rust. Of late years the gas companies' servants generally put in the service pipes of sufficient size, unless there are competing companies, or the pipes are unusually long; when they are sometimes laid too small.

4. *By what is the diameter of pipe to be determined?*

By the pressure available when the light is required; by the number and average size of burners in use at once; and by the length of pipe. If the bends are carefully made in lead pipes so as not to contract the area, these offer less obstruction to the passage of gas than iron pipes.

5. *For what pressure should the pipes be laid from the meter to supply the house?*

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* How to proceed in old houses where the pipes are already fixed, see p. 26.

As gas should always be burnt at a low pressure in order to get its full lighting power, the pipes should be made large enough for the lowest practicable pressure or say $\frac{5}{10}$ at any part of the house. When the average pressure greatly exceeds this at the main, which is generally the case, it can be reduced in the house by turning the main tap beyond the meter, or by using a regulator on the consumer's side of the meter.

6. *What diameter should the pipes have?*

The following table gives the size of pipes to ensure a good supply of gas to a building.

Internal Diameter of Pipe.	Greatest Length of Pipe.	Greatest Number of Burners allowed, burning 5 feet each.
⅜ inch.	20 feet.	3
½ ,,	30 ,,	7
⅝ ,,	40 ,,	12
¾ ,,	50 ,,	18
1 ,,	70 ,,	30
1¼ ,,	100 ,,	55
1½ ,,	150 ,,	100
2 ,,	200 ,,	180

These sizes are estimated for iron pipes with a usual number of bends, and will consequently be ample for lead or composition pipes, if the bends are skilfully made, and not so as to contract the area.

The service pipes should never be less than ¾ inch bore. No pipe less than ⅝ should be used inside a house except as a branch pipe. All iron and composition or lead pipes are measured by their inside diameter, whilst brass and copper tubing is measured by the outside diameter.

7. *What is the best material for pipes?*

In this country wrought iron alone is used for service pipes. In some towns it answers well and lasts a long time, but in others it is rapidly destroyed. The chemical nature of the soil in which they are laid, and of the impurities in the gas determines in most cases the duration of the pipes.

For the supply pipes inside the house the user has the choice of iron or of composition piping. The former is mostly used except for the branches. Its advantages are cheapness, non-liability to get bulged or damaged by having nails driven through, or holes eaten in by rats, defects which, with lead pipes, have led to several explosions. Its disadvantage is a liability of the rust in the inside of the vertical pipes falling down and lodging at the bends, where in time it becomes a serious obstruction until removed by the service cleaner.

8. *What is the second point to determine in laying on the Gas?*

The size of meter (see chapter V.). It is advisable to have the size of meter to correspond with the maximum amount of lights required, although with the usual night pressure in the main, a meter marked for any particular number of lights, will generally pass gas for at least double that number, as it seldom happens that many of the burners will consume as much as 5 feet of gas an hour, for which rate of consumption the meters are usually estimated. The size of the outlet pipe union on the meter, that is, the pipe leading from the meter to the house, usually determines the size of this pipe, when the meter is fixed, and the size of the service pipe is usually also determined by the size of the inlet union on the meter. Should, however, the distance from the main to the meter exceed 100 feet, the service pipe, commencing at the main, should be made larger.

9. *What precautions should be taken in laying pipes in a building?*

A mistake often made by many gasfitters and gas engineers, is in putting comparatively small branch pipes at right angles to the rising main or supply pipes through a building, whereas the branch pipes sometimes require to be nearly as large as the main itself, especially when the current of gas along the latter tends to suck (so to speak) the gas out of the branches, particularly when these descend instead of rising.

It must never be forgotten that too small a branch pipe in any part of a building for the few lights it has to serve may necessitate the maintaining of a much higher pressure throughout the entire building than would suffice if the branch were a little larger. This at once leads to waste, unnecessary heat and other discomforts, and renders the use of a regulator at the meter impracticable.

10. *What other precautions should be taken?*

The meter should be placed in as low a position consistent with this fact that should not be lost sight of, viz., that the service pipe should incline downwards all the way to the main, after the first rise from the meter. Where this cannot be done, then syphons should be fixed in the service pipe to collect the water from condensation.

Still with the object in view of obviating any trouble from the water deposited by condensation, the collection of which is the cause of the gas "bobbing," so often a source of annoyance, the supply pipe from the meter should rise gradually in the building, without any dips occurring in passing beams, walls or doors.

Where these dips or descents in the supply pipe are unavoidable, branches, taps or sockets should be provided at the lowest points for draining off the water which is sure to collect here sooner or later, and possibly be a source of great annoyance.

In leading off a vertical iron pipe upwards from a horizontal pipe or *vice versâ* in positions where a large bend cannot be applied, it is always advisable, instead of using a simple L or elbow piece or T piece, to use instead of the former, a T piece, and instead of the latter a + piece, and plug up the spare socket with a gun metal screw, which can be removed to let out water or rust that may collect. In all cases where practicable, make the bends as easy as possible, that is, of a large radius.

11. *When the "bobbing" of the gas occurs in a building already laid for gas, what is to be done?*

If the course of the pipes cannot be readily improved have the water drawn off and the wet meter replaced by a dry one. Where a wet meter is used, the "bobbing" or "blinking" also occurs when there is an insufficient supply of water in the meter (see p. 46) and where it occurs locally at a gasalier and is accompanied by a smell of gas in the room, it shows that water in the slide of the gasalier is wanted, or that the gasalier has been drawn too far down—a very dangerous practice, for if left in that position overnight the escape of gas past the slide may lead to a disastrous explosion.

CHAPTER VII.

BURNERS.

For Figures, see Plates I., II., and III.

1. *How many different kinds of burners are there?*

There are too many to enumerate. Burners may be divided into two classes; 1st, those with naked lights, and 2nd those with chimnies.

2. *Describe the burners with naked lights most generally used.*

These are shown in figs. 6 to 16. Some of these can be used with or without globes or moons, and the rest without globes only. The names by which burners are usually called are suggested by the shape of the flames, which are mainly due to the shape, size and direction of the orifice, shape of burner top and pressure at which the gas issues from the orifice. According to simplicity of construction they may be arranged asfollows:—

1st. The rat tail (fig. 6), the orifice of which is a very small round hole, from which the flame projects in a long thin jet. Although not to be recommended for lighting purposes, this burner is very useful for many purposes, as, for instance, when connected with a flexible tube for sealing bottles and packets expeditiously.

2nd. The cockspur, (fig. 7), which has three small holes instead of one. This burner is scarcely ever used now, having been replaced by the next in order, viz.:—

3rd. The slit burner (figs. 8 to 12 and 20 to 25).

This is a further development of the rat tail and cockspur, the number of minute holes being increased, and placed so close together that they run into each other and form a continuous slit. The slit burner admits of greater modification than any other, with good results for different purposes. As the shape of the flame depends mainly upon the relation between the size of passage to slit, the width and shape of the slit itself, and also upon the pressure of the gas as it issues from the slit, it follows that with this burner the shape of the flame admits of indefinite variation, and may be a "batswing," "fan," or "tulip" shape as required.

4th. The "fishtail" or jet burner (figs. 13 to 16), or "union jet," as it is more properly called from the manner in which the jets of gas unite and flatten out at right angles to form the "fish-tail" flame. Some varieties of this class have been styled "tulip" burners, but erroneously so, as the outline of their flame does not bear so much resemblance to that of a tulip as the flame outline of some of the slit burners. In fact, "fish-tail" is quite as much a misnomer, when applied to many of these union burners, since a flame much more like an average fish-tail in outline can be obtained from some slit burners. We shall, however, in deference to custom and to avoid being misunderstood call "union" burners also "fish-tail" or "tulip" burners.

3. *What does the number stamped on brass burners indicate?*

The number of feet of gas they are supposed to burn per hour.

4. *But does not this quantity depend upon the pressure?*

Yes, and with common gas of 15 candles, Brönner's burners are marked for about 1 inch pressure; some of "Bray's" that were tried for $\frac{7}{10}$ pressure, and most of the other "union" burners tried are too indifferently constructed and marked to rely upon.

5. *How are cast iron burners and steatite burners and tops marked, that will not bear stamping?*

They have small rings turned in their circumference, the number and size of rings answering to the number of feet of gas the burners are supposed to consume.

6. *Of the burners just described, which is the most generally used?*

Undoubtedly the "union" jet or "fishtail," in one or other of its various makes, either of iron or brass, with "lava," "adamas," "enamel," "porcelain," or "steatite" top.

7. *Are we to conclude that the union is the best burner known from its being most used?*

Certainly not; but, on the contrary, it has proved itself to all who have bestowed any attention upon the matter (excepting, of course, the makers and those interested in its sale) to be the very worst after the rat tail, for common gas, of which it is an offshoot. Fortunately the rat tail is but seldom used.

8. *In which way is the "union" or "fishtail" the worst burner for general use?*

1st. Because the sizes from 2 to 4, which are generally sold and applied by gasfitters, are the worst adapted for getting the light or illuminating power out of the gas at ordinary pressures, that is from 8 to 14 tenths.

2nd. The light becomes worse as the pressure and consumption increase.

3rd. They make the most noise at any but very low pressures. The only advantage they possess is that on a slight increase of pressure their flame is apt to flare up, lose its lighting power, and make a most disagreeable whistling sound; which draws attention to the waste going on.

9. *Are union jets all of the same make and construction ?*

Taking burners of the same size, they are all about the same in principle, and perhaps equally good when new, so far as their efficiency in lighting and their consumption of gas is concerned, in spite of many plausible little devices and contrivances introduced, more for the purpose of deceiving than of benefiting those who purchase them. They begin with the old-fashioned union jet, made of cast iron, retailed at 3*s*. 6*d*. per gross, and pass through innumerable grades to some of the so-called patent burners made of thin brass, and having tops of baked clay variously called "lava," "adamas," "steatite," or "enamel" according to the fancy of the maker, and sold at 1½*d*. to 6*d*. each. The small sizes are for most purposes dear at any price, as usually sold and applied, seeing that they are too often the cause of the waste, bad light, and gloomy and cheerless rooms complained of all over the country. Those baked clay tops have undoubtedly the advantage of not corroding and becoming worn out so soon as those of cast iron, but they have the disadvantage of being liable to be nipped out or drop out.

A comparison of the union flames, the outlines and particulars of which are given in figs. 17, 18, 19, with slit burners in figs. 20 to 25, will convince anyone of the badness of small union burners.

10. *If these union or fishtail burners are so*

generally preferred, there must be some reason for the preference shown to them?

Doubtless; and the principal reason is that all slit burners are usually called "batswing" burners. Now with ordinary pressures, from the shape of their flame, union burners can be used with globes, whilst the old-fashioned "batswings" cannot, as their wide-spreading flame would be liable to break the glass, *see* figs. 24 and 25, and as all slit burners are usually called "batswings," they are at once set down by those who ought to know better, and therefore by all who speak after those (but who don't know better) as being unsuitable for general use. Hence the "union" jet burner has hitherto had the field almost to itself. A glance at the shape of the flames of union and slit burners in figs. 17 to 19, and 20 to 23, will convince any one of the absurdity of excluding slit burners indiscriminately from the list of burners suitable for using with globes.

11. *What other circumstances cause the fishtail to be such a favourite with gas fitters and the public?*

One reason is, that with ordinary high pressures, "batswings" are wasteful of gas, although they give a good light; and the very fact of their giving notice of the quantity of gas they are passing by the large strong light, warns users of the consumption going on, and the burner condemns itself, whereas, with the smaller sized union jet burners, which are so largely used, the light with ordinary high pressures is often so feeble and gloomy, and the waste of gas unperceived, that, instead of feeling there is room to economise, the user is inclined to do just the reverse of what he should do to improve the light, not knowing what he ought to pay for the light he is getting. Now as the first cost of fishtail burners is small, consumers are content to have them replaced frequently, being advised this is the best way to ensure having a good light. And as the retail dealers, who are mainly gas fitters, get a good profit on them and have no trouble, they recommend fishtail burners before all others.

12. *But are there not some persons who, having tried all kinds of burners, prefer the fishtail to all others?*

Yes, and for special work such as compositors', designers', engravers', and others, where the advantage of having a stiff, steady flame outweighs all other considerations, some fishtails, as a rule, answer better than some slit burners, yet with equal pressure, and where a very strong light is required, and there is no draught, there are slit burners that will answer quite as well or better than a fishtail for engravers, and others who require a strong light; also in exposed and draughty situations, as in halls, passages, and in sunlights, the stiff but not very brilliant flame of the fishtail is often preferable to the more flickering and smoky flame of the slit burner. Although the union jet is not so easily cleaned as the slit burner, it will, however, go longer under equally unfavourable conditions of dust and disuse, without requiring cleaning. Moreover, as the gas passes through the holes at a greater velocity in the union jet it is a better self cleaner, hence it may with advantage be used in lofty and inaccessible situations, and here the old-fashioned cast iron burner is perhaps the best to use for sunlights, as it has no top to drop out.

13. *Is there anything inherently defective in the principle and construction of the fishtail or union jet?*

Yes; the shape and direction of the flame being dependent upon the striking together and flattening out of the two currents of gas that issue through the holes, if these two currents do not issue at the same angle and with the same force there will be a waste of gas from the preponderating jet at anything but very low pressures. The union jet or fishtail does not admit of being easily cleaned, like the slit burner, with a piece of stiff paper, and when it becomes partially choked after being in disuse it has to be replaced by a new burner. With excessive, but by no means unusual, pressure it allows, more than any other kind of burner, a quantity of gas to pass off unconsumed that cannot be detected by the eye; and is very wasteful at ordinarily high pressures.

14. *Is the opinion of the unsuitability of fishtail burners based upon experience?*

Yes; the opinion is based upon experience in all parts of the kingdom, and on the knowledge that tens of thousands of these burners, of all sizes and makes, have been and are being replaced by burners with slit tops, with great saving in health, comfort and pocket.

15. *Then as a rule fishtail burners should only be used in exceptional cases?*

Yes; for until their general use is abandoned, we shall have no general improvement in gas-lighting.

16. *Is there no way of redeeming the fishtail?*

Only one, and that is to make a check burner of it, on the "Brönner" principle, and then, when the force of the current of gas is reduced, the burner will lose its present one redeeming point, inasmuch as the current of gas will not clear the holes of dirt, and in consequence they will readily choke, whilst their shape forbids the adoption of any ready mode of cleaning them like a slit burner.

SLIT BURNERS.

1. *Is not the batswing burner so called after the shape of the flame?*

Yes, but as we have already said, the name batswing is usually but wrongly given to all slit burners, the flame of some of these latter being much more like a fish-tail than that of a union jet.

2. *Is the slit burner better than the fishtail?*

Decidedly so for general purposes, at the low pressures at which gas should only be burnt for lighting purposes, but for the high pressure at which gas is generally used, ordinary slit burners, like large fishtails, are very wasteful. The old-fashioned "batswing" burner, is however, too wide spreading to be used with ordinary globes.

3. *Are there any burners with slit tops suitable for globes?*

Yes, the burners that have proved themselves to be the best after a test of years for general purposes, such as Brönner's and Sugg's flat flames, are made in such a manner that they can be used with globes, and are quite as good as fishtail burners in this respect.

4. *Why is the slit burner better than the fishtail for general purposes?*

Because it burns the gas under conditions more suitable for its proper combustion.

5. *Is the old-fashioned batswing in iron or brass then to be recommended?*

No, it is far too wasteful at ordinary pressures; merely the shape of the slit for a burner top is here recommended.

6. *What then beyond the top is required?*

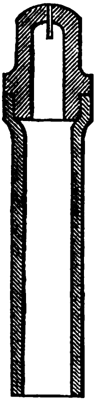
There is no burner made consisting of only sides and top that is worth anything as a burner for general use, if we wish to burn gas as it ought to be burnt. What is required is something at a distance from the burner top, either to check or to regulate the flow of gas, and allow it to burn slowly and perfectly as it passes out of the slit.

CHECK BURNERS AND REGULATING BURNERS.

1. *What can properly be called improved burners?*

Only those that check or obstruct, and those that regulate effectually the current of gas so that it does not issue at the point of ignition with a velocity greater than that due to about $\frac{3}{10}$th pressure.

Fig. 26.



TEST-BURNER TO PLACE OVER FISH-TAIL BURNERS.

2. *How can you prove that it is wasteful to burn gas with common burners at ordinary pressures?*

By a very simple experiment. Make a test burner of indiarubber tube, $\frac{1}{4}$ inch in diameter (inside), and about 2 inches long, provided at one end with a large slit burner or burner top, see fig. 26. By passing the open end over the top of a No. 3 or 4 fishtail burner and lighting the gas at the top of the test burner, it will be found that with ordinary pressures in the gas-pipes, say of $\frac{9}{10}$ths to $\frac{16}{10}$ths, the flame will be nearly double in size. This experiment should be made without touching the gas tap. Now as the small burner remains where it was, it is evident that the same quantity of gas is burnt as before. With a little practice, the indiarubber burner can be applied to the other without extinguishing the light. Now as a much greater light can be obtained with the same quantity of gas it follows that equal light can be obtained by a proportionately less quantity of gas. This experiment cannot well be made with an ordinary slit burner, as the tube will stop the sides of the slit. It is only with low pressures that this experiment cannot be made very striking, and the smaller the fishtail burner below, and the greater the pressure of gas, the more marked will be the improvement of light. Not only will the flame become much larger, but of a much whiter colour. It will be observed in making this experiment, that if the upper burner be too large in proportion to the under burner and the pressure, the flame will be smoky. The burner with small orifice below, opening into the chamber of the indiarubber tube, terminating in a large slit, is the principle of the Brönner burner.

3. *Which of the numerous burners in use can be recommended?*

"Brönner's Patent," and "Sugg's Patent Regulating," may be taken as examples respectively of the two types of check and regulating burners, the former being much simpler in construction.

4. *Describe Brönner's patent burner.*

It consists of a small brass cylinder, about ⅜in. diameter (see fig. 10), having a short slit burner of steatite screwed into the top. Externally there is a thread and collar to receive the triangle or "gallery" for the globe. Inside the lower end, which is contracted, a piece of steatite is inserted, having an oblong orifice of an area much less than that of the vertical slit at the top. The flow of gas is checked on meeting the bottom of the burner, and on passing through the aperture, it expands into the cylinder or body of the burner above, and issues from the top slit at a pressure of from $\frac{3}{10}$ths to $\frac{4}{10}$ths.

The size and number of the burner is determined by the size of the orifice in the bottom check piece which is the important feature of this burner, and should be treated as such in fixing it.

5. *How many different sizes of Brönner's burners are there?*

The burners are made with 11 different sizes of orifice in bottom, consequently there are 11 different numbers of burners. Nos. 1, 2, 2½, 3, 3½, 4, 4½, 5, 6, 7 and 8. These sizes indicate the number of feet of common gas the orifice is capable of passing at about 1 inch pressure, and there are 5 different sizes of cannel tops—8 B tops, and 2 A tops, or 15 sizes of tops of three different kinds, making in all about 80 combinations or relations between top and bottom orifices to suit all the various qualities of gas, pressures, and conditions of lighting required.

6. *Describe the three kinds of tops.*

There is first the flat, or A top as it is called by the makers (fig. 20), which is used with poor quality gas, giving a long narrow flame, and is only suitable for using with a globe to steady the flame. Secondly, the circular or B top, which, with gas of inferior quality, gives an excellent, wide-spreading batwing flame (figs. 10 and 21). As both these tops are totally unsuited for burning cannel gas, the third or cannel top (figs. 12 and 22), is made, having a much finer and smaller slit, suitable for burning cannel and good common gas, either with or without a globe.

7. *What advantages are derived from the use of these Brönner burners?*

1st. As compared with the favourite improved tulip and fishtail burners so generally recommended by the gas-fitter, a saving at ordinary pressures in the consumption of gas of at least 25 (but oftener 50) per cent. can be guaranteed, with equal light. 2nd, Less unconsumed gas, consequently less vitiated air. 3rd, Less heat; and 4th, when proper globes are used, not only a steady, but also a more cheerful, softer, and better light. When once properly fixed, the burner, with its bottom check piece, becomes part of the gas fittings. The top will last at least 10 years without deteriorating, and should it accidentally get broken, it can easily be replaced at a trifling cost. The slit in the top can easily be cleaned at any time, when necessary, by a piece of stiff paper, or a straight piece of watch mainspring. With proper globes, to ensure steadiness of light, these burners are not surpassed by any for lighting public and private buildings, either in economy or efficiency, but they must be selected and applied according to the quality and pressure of gas. The scientific accuracy, with which these burners of Brönner's are made, enables any one after a little experience to predict with certainty the amount of light and consumption they will give, once the quality and pressure of the gas is known, and this is one of the chief reasons why their use is here so strongly advocated.

8. *Are there not some check burners made with a very primitive contrivance to obstruct the gas?*

Yes, these may be called stuffed burners. One of these, Leoni's jet, is shown in fig. 16, which has a piece of cotton wool inserted just above the bottom portion. As the size of the passage through the cotton wool is very uncertain, the consumption of gas cannot be accurately determined, consequently these burners cannot be used to ensure any particular consumption at any given pressure, but they are a very great improvement on the old fishtail, and have given excellent results, especially where the pressure is not great.

There are Bray's, and other similar fishtail burners, fig. 15, which are more used than any other so called improved burner. The obstruction here is a piece of calico placed a short way below the top of the burner. In the sizes of these burners mostly used—Nos. 3 and 4—the obstruction does not appear to be of any use, since at ordinary pressures—$\frac{8}{10}$ths and upwards—a better light can be obtained with much less gas by using a burner with a proper check piece below such as Brönner's.

A union light can be made by arranging two rat-tail, fishtail, or slit burners so that the flames meet at an angle. With a wasteful pressure of gas at the point of ignition, the light from the combined or union flame is much better than that from the two flames apart, but there is comparatively little improvement of light when two check burners are thus used.

9. *What precaution must be observed in using check burners?*

Not to carry the system too far, or the flames will be liable to smoke. The only objection to developing the utmost amount of light from gas with any burner is that the flame is apt to flicker and smoke when affected by currents of air. In dwelling houses it is advisable to use cannel tops with Brönner's burners when the quality of the gas is over 15 candles, with a view to prevent the flames from smoking. The light may be slightly reduced, but the ceilings will be saved.

The richer the gas, the more liable is the flame to smoke, and the greater the care necessary to burn the gas properly.

10. *Describe what is sometimes wrongly called a regulating burner.*

The so called regulating burner differs from Brönner's burner inasmuch as the size of the bottom orifice can be altered at will by a small valve to suit the pressure. But inasmuch as the upper side of this valve is not subject to the atmospheric pressure, it is not really a regulating burner after all, like the Sugg self-regulating burners used on the street lamps in large towns, and being usually very indifferently made, is not so good as a simple check burner.

11. *Describe the self-regulating burners invented by Sugg.*

The pressure of the gas, after passing through the bottom orifice acts upon a flexible diaphragm, carrying a brass valve which has the underside of the bottom orifice for its seat, so that any increase of pressure tends to close the valve. The opening of the valve can be adjusted by means of weights to any pressure, that of half an inch being usually chosen for street lamps.

12. *What objection is there to the use of self-regulating burners?*

As a rule they are too cumbersome, and the large governor or regulator chamber, by intercepting the light downwards, casts a shadow below which renders most of these burners unfit for sitting rooms and other gasaliers, where the light is required below as well as on all sides. Moreover nearly all the small-sized regulators used with batwing burners, are little if at all superior to check burners such as Brönner's.

13. *For what purposes are good self-regulating burners most suitable?*

For street lighting, where the gas is burnt over a large district for a length of time during which it is subject to great variation of pressure.

THE ARGAND BURNER.

14. *What is an Argand burner?*

The Argand burner differs widely from the others, never being used for a naked light. It consists of two thin metallic cylinders, one within the other, forming an annular space into which the gas is admitted, and from which it issues through several very small circular holes in the top of the ring, where it is burnt, forming a continuous circular flame. As the air has access both to the inside and outside of the flame it can become intimately mixed with the gas.

15. *But as the air would be in contact with the gas on both sides, and at the ends as well, if the holes were in a straight line, wherein lies the advantage of the circular flame?*

In its being the best form for applying a chimney, by which a draught is caused. This draught can be increased or diminished by increasing or reducing the height of the chimney. As the light of an Argand flame, like that of naked lights, may be reduced by too small or too great a supply of air, it follows that for each quantity of gas consumed, there is an amount of air which gives the best result, hence the proper height of chimney varies with the consumption of gas. The consumption will be regulated by the pressure, and quality of gas, and by the size and number of the holes in the burner.

16. *What is the great advantage possessed by the best Argand over all other burners?*

For photometrical experiments they give a higher illuminating power when burning common gas, than any other burner that is much used.

17. *But is the photometrical result found in the testing room, always to be taken as deciding which is the best burner to use?*

By no means, for, although the illuminating power found in photometrical tests gives the efficiency of the burner with any given kind of gas, these tests cannot be considered as determining the general practical value of any kind of burner.

18. *Is this so in the case of the Argand burner?*

Yes, the best Argand burners cast such strong shadows as to very materially reduce their value, when placed above the level of the eye. Consequently when used for desks and other places where a good light is wanted below, a "shade" is necessary to reflect the light downward, which unfortunately intercepts and destroys the side light by which their efficiency is measured in the testing room.

19. *What other disadvantages are there in using Argand burners?*

Ordinary Argands are unfit for using with rich cannel gas. They are very apt to smoke unless they are constantly attended to. They cause trouble by breakage of chimneys. They are costly, they get choked up unless well attended to, which renders them unfit for inaccessible situations. They become very hot, and as the shade reflects the heat downwards they become unbearable, unless placed a considerable distance above the head of the gas user.

20. *For what purposes is the Argand suitable?*

For lighting up shop windows externally, and for places where a strong steady light is required, and smoke and heat are not objectionable.

CHAPTER VIII.

GASALIERS.

1. *What is the first point to decide in selecting a gasalier for a house?*

The number of lights it should have.

2. *How many lights are necessary for an ordinary sized sitting room?*

For a room not over 18 ft. square × 11 ft. high, with a white ceiling and light coloured walls, one light even with only 15 candle gas, consuming about 5 ft. an hour at a height of about 6 ft. 6 in. or 7 ft. from the ground should be quite sufficient. But this single light should be a good one, and there should not be much dark, heavy drapery in the room, and it must not be expected that the far corners of the room will be lighted sufficiently to read in.

3. *Are good rooms of such a size ever fitted with a single light pendant?*

Very rarely, if ever, because single light gas pendants designed or constructed for fixing in handsomely furnished rooms are seldom met with, although there are plenty for oil lamps.

4. *Is not this very strange?*

Not stranger than that gas-fitters seldom understand their business (in one sense at least).

5. *What is the smallest sized gasalier usually found with some pretension to elegance in design?*

A three-light, yet there are a few passable two-lights to be found.

6. *What objection is there to using a three-light gasalier when a single-light will do?*

Since the three-light is chosen for its appearance before the single-light, we may assume that in consistency all the three lights will be burning when the gas is used. Now with the best fishtail or union burners in general use on gasaliers, it is impossible with three small burners to get the same amount of light, at ordinary pressures, with anything like the same consumption of gas that can be obtained from a single large check burner. For instance a good burner, say a No. 5 Brönner, consuming 5 ft. of gas at 1 inch pressure would light the room well, whereas, with the same pressure three good fishtails would consume about 10 or 12 ft. of gas and give only the same amount of light. No doubt by using a regulator or manipulating the taps carefully, and applying larger fishtail burners the same light might be obtained with a little more consumption than with the single light. But this careful manipulation is what cannot be reckoned upon in using gasaliers.

7. *Is there no class of burners, that, with a given ordinary pressure in the pipes, will give a light proportionate to the amount of gas passed through, no matter what size is used?*

Yes, Brönner's burners can be trusted to do this, and no doubt by their use a three-light gasalier could be made to yield as good a light with three small burners as a single light with a large burner, with very little additional consumption of gas.

8. *Why the additional consumption?*

Simply because in using three globes, instead of one, three times the quantity of light is absorbed, hence to have the same amount of light in the room, a larger consumption is required to give the surplus amount of light at the burner, which has to be absorbed.

9. *Why are not good check burners more used with gasaliers?*

Because few gas-fitters have the knowledge and skill to apply them properly.

10. *Then as a rule the fewer lights the better?*

Yes, for a small room, having regard to health and economy, as well as comfort.

11. *What sized gasalier should be chosen for a large room?*

With a view to comfort and economy it is not advisable to have gasaliers with more than 3 or 5 lights. As the light increases inversely as the square of the distance (that is, a light of 25 candle power at 3 ft. from the burners, towards one side of a room, has only about one candle power at a distance of 15 ft. from these burners) it should not be attempted to light the ends of a long room or table by a single gasalier in the middle. Suppose a dining table 26 feet long be lighted by a gasalier in the centre, whose light is equal to 9 candles at any point round the centre of the table, 4 ft. below, then as the ends of the table are about 12 ft. from the burners there will be only about one candle light here. In such a case it would be much better to have two gasaliers 5 ft. from each end of the table, with the number of lights divided equally between the two gasaliers. We should now have 4½ candle light beneath each gasalier and nearly 3 candles at the ends and middle of the table. If one candle power be sufficient at the ends of the table as in the first arrangement, it is evident that rather over one-third the quantity of gas will suffice, showing the latter is a much more economical and healthy arrangement than the former, and gives a more uniform light. In like manner in lighting a large square room it is preferable to have two or more gasaliers properly distributed than a single large one in the centre. Or a single gasalier of moderate dimensions in the centre may be used, if brackets are also used at the walls round the room. By distributing the lights properly, a much more wholesome atmosphere can be maintained with a more uniformly distributed light throughout the room.

Of course where there are special arrangements for efficient ventilation in connection with the gasalier, or where the light is placed a considerable distance above the users' heads, as in a sunlight, then one large gasalier is to be preferred, from a sanitary point of view, and also with regard to economy, when the deleterious and destructive results that may arise from the sulphuric acid left in the room are taken into consideration, as well as the consumption of gas.

12. *What is the second point to be attended to in choosing a gasalier?*

The height. As the light decreases so rapidly with the increase of distance at which it is used from the burner, it is of the first importance not to have the lights too high, and yet they should be of such a height in a dwelling house as to leave head room beneath when required. For sitting rooms the gasalier, when of the sliding kind, should be, as a rule, so arranged that there is a clear height of 6 ft. 4 in., when the gasalier is pushed up as high as it will go, and when drawn down the burners should be about 5 feet above the floor, to give a good light for reading or working by at the table underneath. This is also a convenient height for lighting the gas from above, as should always be done to avoid smoking the globes, which is the almost inevitable result of an attempt to introduce a light from below.

In large and lofty rooms, both for appearance sake and in order to distribute the light, a greater height is required, and should be decided by the number and power of the lights, and by the space to be lighted.

13. *What is the third point that requires attention?*

As the light is always required below there should be no obstruction to prevent the passage of the rays of light downwards, in the shape of heavy "galleries," discs, leaves, triangles, rings or other articles of questionable taste for supporting the globes. These all throw a strong shadow below, and may intercept 75 per cent. of the light where it is most wanted. All that is required is simply a shadowless triangle, made as lightly as possible, yet always with due strength. The nakedness of the burner socket can be relieved with a small leaf or other suitable ornament.

14. *What precautions should be used in selecting a gasalier?*

To have its tightness at 2 inches pressure guaranteed.

15. *What precautions should be used in fixing the gasalier?*

To have the weights balancing the body, &c., properly—a change of globes sometimes affects the weight materially—and to have the weights so arranged that the gasalier cannot be drawn down further than necessary, or so far as to risk an escape of gas past the slide, even when it is tolerably well supplied with water.

16. *What is a sunlight?*

A sunlight consists of one or more clusters or rings of lights placed near the ceiling. Each cluster usually consists of half a dozen or more burners fixed horizontally round a flat circular chamber, from which they radiate outward. The clusters are arranged underneath a bell-mouthed hollow cone, which acts as a reflector and also as a ventilator, the upper portion being in communication, more or less direct, with the outside of the building.

17. *Where should sunlights be used?*

In libraries, dining halls, and public and other buildings, where it is all important that the steam, carbonic acid, sulphuric acid, and other products of combustion and exhalation should be carried off by a strong draught, which this system of lighting eminently favours, and where the large consumption of gas in proportion to the light obtained where required, is justified by the advantages a sunlight offers.

18. *Why is it a wasteful mode of lighting?*

Because the light is placed at the furthest possible distance from where it is required.

CHAPTER IX.

GLOBES.

1. *Why are globes used?*

1st, to improve the steadiness of the light and prevent flickering. 2nd, to diffuse and soften the light, and remove any painful or wearying effect a glaring light may have. 3rd, For appearance, and 4th, in bedrooms and other similar places for safety. In making choice of a globe these considerations should be kept in view.

2. *What great drawback, theoretically speaking, attends the use of globes?*

They absorb a great amount of the light. This loss is, however, considered to be outweighed by the improvement in the steadiness and softness of the light. The amount of light absorbed depends upon the size of globe, and quality and thickness of material. Large globes absorb more light in a horizontal direction than small ones, but they diffuse the light better, and when the bottom opening is proportionately large, as it should be within certain limits, they give a better light than small globes where it is usually most needed, that is, below. Moreover if the bottom opening be not large enough to allow the upward current of air to ascend without impinging strongly against the flame, it will cause the flame to flicker. This is a most important consideration, and if lost sight of, the purpose for which the globe is applied may be defeated. As a rule the diameter of the bottom opening should always be slightly larger than the width of the flame to ensure a steady light.

Globes, shades, or moons as they are variously called, are either transparent or translucent. The former, of course, absorb less light than the latter. The percentages of light absorbed by globes of different materials and make, are given below.

	Approximate amount of Light absorbed.
Globes of clear glass from	10 to 12 per cent.
,, slightly frosted	25 ,,
,, clear glass and ground designs from	25 to 35 ,,
,, ground all over	40 to 50 ,,
,, thin opal or cornelian . . .	35 to 40 ,,
,, thick opal	60 to 70 ,,

3. *What are the relative merits of globes of different shapes?*

There is an endless variety of shapes and designs. The three types mostly used are shown in figs. 27 to 29.

Fig. 27.

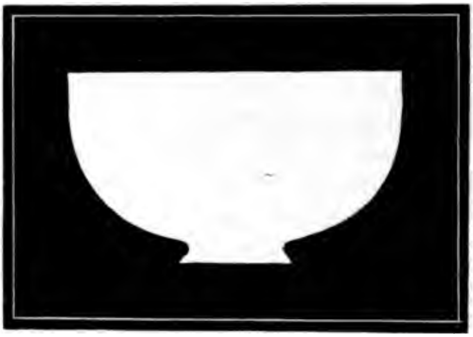


Fig. 27 is a " saucer " globe, or rather " shade." This type varies in shape from that of a shallow saucer to that of a deep basin. The great defect in all shades of this type, is that the flame is exposed to currents from above which are ever present in a room, where a light is being used. The result is a flickering, and often very smoky flame, unless the gas is ineffectually burnt at an extravagant and unjustifiable pressure. When these shades are used in rooms with well kept white ceilings, a large proportion of the light is reflected downwards, and well diffused throughout the room. On this account alone this type is good in principle, and it may be made of very graceful form, but in consequence of the unsteady light it gives, it cannot be recommended for general use.

Fig. 28.

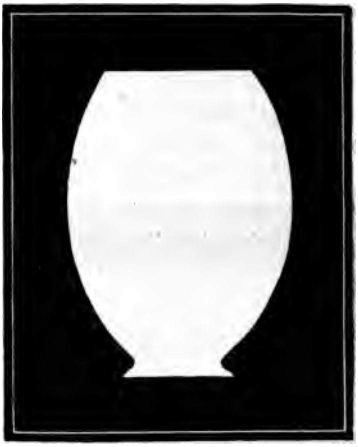
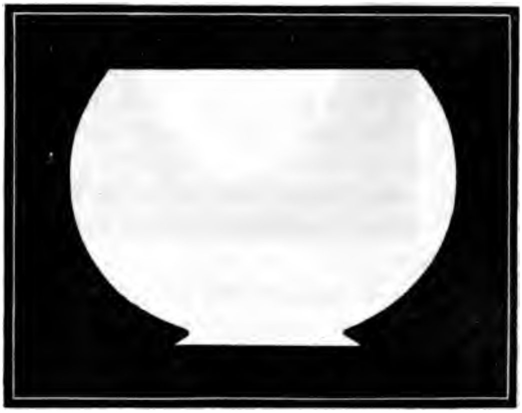


Fig. 28 is a "barrel" or "pine-apple" globe. This varies from a "pine-apple" to a sphere, in shape. In the "pine-apple" form the upward current of air impinges too forcibly against the flame, and the flame is liable to crack the globe when turned full on at first. For these reasons it should be used only with a small flame, such as is required for bedrooms, for which this shaped globe has the further advantage of being the safest, as it best shields from the flame the curtains, &c., with which it may come in contact. By enlarging the openings above and below, reducing the height, and increasing the diameter, this can be made an excellent globe for increasing the steadiness of the light, and shedding it downwards, but it then becomes anything but a shapely object in the eyes of many people. Fig. 29 may be called a "spherical" globe. By keeping it well open below, as it already usually is above, it can be made as good as the "barrel" shape for ensuring a steady light, and reflecting it downwards, and it is much more shapely.

Fig. 29.



4. *Taking the "spherical" and "barrel" globes to ensure steadiness of light, which material is best?*

For watchmakers, engravers and others, the clear glass is doubtless the best, when a good strong light is of the first importance, but for rooms private and public, where a pleasant light is required, no material is so good as the thin opal or cornelian. Perhaps the best of these are the Brönner globes, which are very light, being little thicker than an egg-shell, and, when handled with ordinary care, are not more liable to break than heavy glass globes. They are far less liable to break from sudden contraction when hot, or from sudden and unequal expansion on lighting the gas. In fact when used with a Brönner burner consuming 5 feet of gas an hour, one of these globes will remain so cool that the hand can be borne on it, whereas the heat of an ordinary glass globe would be unbearable.

5. *What are the loose tops used for, so often seen on globes?*

Those "talc" tops are mostly made of mica, and when properly fitted to the globes serve three purposes. 1st, They arrest the upward current of air, and by increasing the temperature within the globe, tend to improve the light and prevent the production of smoke. 2nd, When there is a good wide opening in the globe below, they reflect a considerable amount of light downwards where it is usually most wanted, 3rd, They distribute the ascending current of burnt gases over the room, and so prevent any local blackening of the ceiling. These tops or covers should be fitted to the globe as closely as possible, yet not so as to check the draught too much.

6. *What precaution should be taken when choosing a globe?*

To be sure you can get it matched readily in case of breakage.

CHAPTER X.

REGULATORS.

1. *What is a gas regulator or governor?*

It is an apparatus designed and applied to keep the pressure and supply of gas constant and regular inside the building where it is used, notwithstanding the great and continual variations of supply, as the pressure varies from $\frac{5}{10}$ths to $\frac{20}{10}$ths in the street mains, and also for keeping the consumption at the burners constant, whether there be few or many lighted at the same time. Whilst they are intended to prevent any excess of pressure beyond that at which they are set, (usually about $\frac{8}{10}$ths,) regulators are expected not to check the proper supply of gas.

2. *Where are the regulators applied?*

Usually close to the meter only. Sometimes, however, they are applied, as they should be, at each storey of the building.

3. *No doubt these regulators have been found invaluable in practice?*

In some cases they have, but not in others. Neither theoretically nor practically is the use of a single governor so valuable as it is considered by many authorities to be, and in consequence of the ignorant mode in which regulators have been applied to existing pipes and burners, even by their inventors, the promised results in saving and comfort have too often not been attained.

4. *Give an instance of their misapplication?*

One of the grossest instances, and one of every-day occurrence, is the ignorant application of a regulator to a system where only one size of burner is used. Instead of considering the size of pipes in various parts of the building, height of burner above governor, amount of light required and applying proper burners to suit these, a uniform size of burner is applied all over a large and lofty building, the consequence is, that notwithstanding the constant pressure of gas resulting from the use of the regulator at the meter, there is still a great waste of gas, and an intelligent man can still effect a further saving of 25 per cent. at least in the consumption with a better light, by judiciously applying proper sized check burners.

5. *How does this come to pass?*

In many cases when the cooking, &c., has to be done by gas, a pressure of at least $\frac{8}{10}$ths at the regulator is necessary to effect the heating sufficiently rapidly, through the usual style of soldered up pipes, sharp bends, and gas apertures partly choked up with dirt. Now even $\frac{8}{10}$ths is far too high a pressure to get the most light out of the gas, $\frac{3}{10}$ths being nearer the mark, and in a four storey building the pressure will be at least $\frac{12}{10}$ths at the top storey, which is still worse. Then again on the ground floor or second floor the pipe that supplies, say, a five-light gasalier, is probably only sufficiently large to allow the gas having $\frac{8}{10}$ths pressure at the meter to produce 2 or 3 tenths when all the taps are full open; with the ordinary sized union jets in use this pressure is too low to give anything but a miserable light. So here we have, in spite of the use of one of these regulators, upstairs with an ordinary so-called improved No. 3 or 4 burner, as usually applied, a consumption of 5 or 6 feet per burner, whilst downstairs the consumption may be only 1½ feet.

6. *So then regulators may not be of much use after all?*

Not unless they are applied judiciously at each storey with ordinary burners of large size, or at the meter only with check burners to suit the different pressures in the building. With already existing fittings and pipes, the place to reduce the pressure is at the burner. Even in a small dwelling house of 10 or 12 rooms, at least four or five different sized burners should be employed to use the gas economically and efficiently. Once the burners are applied properly, then a regulator may be of service. It is, however, a fact that a system of properly selected burners applied without a regulator at the meter are much better than a system with never so good a regulator, and burners applied in the usual stupid way. In the former case any undue pressure can always be checked by turning the tap at the main, to give from $\frac{6}{10}$ths to $\frac{8}{10}$ths pressure with the average number of lights burning, and when the pressure is highest in the main.

Any attempt to check the consumption at a high pressure by using very small burners, which are not check burners, is a sure indication of ignorance of the principles of gas-lighting, as it usually diminishes the light to a greater extent than it saves the gas.

7. *Then what conclusion must we arrive at with respect to the use of regulators?*

That they are theoretically necessary for the perfect use of the burner, after the burners have been properly applied in various parts of a building, but practically, for want of proper knowledge in applying them, they have often been found rather a disadvantage than otherwise.

8. *Then how should the governor be applied to meet both the theoretical and practical conditions of the case?*

Either at first apply one governor to give the desired pressure, after it has been found which is the lowest pressure at which an adequate supply of gas will pass through the most obstructed parts of the pipes, and then apply good check burners of different sizes throughout the building, according to the pressure in the different parts, and according to the amount of light required. Or, supply a governor to each storey, and provided the pipes are sufficiently large, and the governor is properly adjusted, the same sized burner can be used with advantage throughout the building, the pressure being the same throughout.

CHAPTER XI.

CARBURISERS.

1. *What is carburisation or carbonisation?*

A method by which it is attempted to improve the richness of gas by passing it, after it leaves the meter, over liquid hydrocarbons, such as naphtha, petroleum, &c., which give off, at ordinary temperatures, vapours rich in carbon.

2. *What effect has this upon the gas.*

The gas takes up the vapour laden with carbon, which increases the illuminating power.

3. *Why have the attempts at carburising not been generally successful?*

They have usually been successful for a while, but have been given up in consequence of the amount of attention the system requires, without which the evaporation of the liquid is not regular for any length of time.

4. *What effect has this?*

It causes burners that are suitable for the gas at one stage of the process, to be totally unsuited at another stage. Burners suitable for the carburised gas in the last stage of carburising, will burn the gas with a smoky flame in the first stage of the process.

5. *What other disadvantages has the system been proved to have?*

The vapours are very often non-permanent, and condensing in the pipes and fittings, cause the partial or entire choking up of these. After having been a source of great annoyance, the carburising vessels have generally speaking been removed or their use discontinued.

APPENDIX.

GAS ENGINES.

1. *What is a gas engine?*

An engine worked by a succession of explosions produced by firing a mixture of coal gas and air. These explosions being under control, both in respect of intensity and number, the engine can be regulated as to speed and power as nicely as a steam engine.

2. *What are the advantages of a good gas engine compared with a steam engine?*

A gas engine up to 3 horse-power can be worked at a fraction of the cost usually required to work a steam engine of equal power. As the gas engine requires no boiler, there can be no boiler explosion. There being no risk of fire as there is in using a boiler, ordinary insurance rates are not affected by the use of a gas engine. As there is no steam to be got up, a gas engine can be started at a moment's notice. There being no fire, there are no coals, ashes, dirt or smoke. As there is no water level to watch carefully, or fire to look after, scarcely any attention is required.

3. *Then with these advantages, why is there so much prejudice against the gas engine?*

Mainly because in the earlier gas engines of the horizontal type, the attempts to utilise the force of the explosions for driving a piston and turning a crank and heavy fly wheel, as in a steam engine, resulted in failure, from a commercial point of view. Consequently there are very few of these earlier gas engines at work now.

4. *Why was it a mistake to attempt to drive a gas engine like a steam engine?*

Because in a steam engine the sustained, although not constant, pressure of steam behind the piston is admirably adapted for turning a crank, the motion of which is kept regular by the momentum of a heavy fly wheel, whereas, in the old gas engines the sudden expansive force or explosion of a fired mixture of coal gas and air cannot well be utilised in producing the steady motion of a crank and fly wheel directly through a piston and connecting rod.

5. *Why cannot the force of an explosion be utilised in this way?*

When the mixture of air and gas is ignited, the heat suddenly generated is equal to that which would be developed if the combustible gases were burnt more slowly, and the temperature at the moment of uniting is probably over 5000°. The effect of this high temperature is to expand suddenly the residue of the air and the carbonic acid and steam produced by the combustion, and it is this sudden change of volume of the gas in expanding, that is called an explosion. Could anything like this high temperature of the gases be maintained in the cylinder, without offering any practical difficulty to the working of the engine, then the gases might be made to exert a sustained pressure against the piston and turn the crank and fly wheel as efficiently as the steam in a steam engine cylinder. But as a temperature far below this would melt the cylinder, it is needless to explain that it cannot be maintained.

6. *But does not the excessively high temperature prove injurious to the material affected by it?*

If the gases can expand and come in contact with a large cooling surface, no injurious effect will arise, if the volume of the gases be kept within moderate limits; but if their sudden expansion is too strongly resisted, and the heat can be carried off by a small surface only, then there is a risk of the high temperature affecting the metal. Surrounded by metal at ordinary temperatures the gases instantaneously condense by cooling; that is, the expansive force by which it is sought to produce mechanical motion is spent in an instant. Hence it is necessary that the gas engine should be so arranged as to utilise this sudden force.

7. *Explain in other words the rationale of the working of a gas engine.*

The *potential* energy of the chemical affinity of the combustible gases at the moment of ignition is converted into *actual* energy in the form of heat. If this heat cannot be at once converted into mechanical motion by the expansion of the gases, it will be mainly expended in raising the temperature of the bodies that bear the shock of the explosions; that is, in a gas engine working like a steam engine, the cylinder, piston, piston rod, connecting rod, crank, shaft and bearings, will all be raised in temperature at each violent explosion, and the cylinder would be rapidly melted if it were not kept cool by a continuous current of cold water. Now this is what must occur in attempting to utilise a *sudden* explosion of gas directly to turn a crank and fly wheel, and in consequence all such attempts have resulted in commercial failure.

8. *Then how can the actual energy of the heat be utilised?*

As in the Otto, Langen and Crossley Atmospheric Gas Engine, which has a vertical cylinder, the top of which is open to the atmosphere, and in which the piston is free to move upwards by the expansion of the gases. At each explosion the piston is driven upwards like a shot. When the piston has reached the top of its stroke, the gases instantaneously condense and produce a vacuum of about 11 lbs. per sq. in. The pressure of the atmosphere added to the weight of the piston and rod forces the piston down. It is only in the down-stroke that the piston does any actual work in turning the fly wheel shaft. Here the actual energy of the heat is converted into potential energy, which again is converted into actual energy by the descent of the piston which produces useful mechanical motion, without any great loss of heat. By the aid of a very ingenious and simple contrivance the motion of this Atmospheric Gas Engine fly wheel is maintained quite as regular as that of a good small steam engine under a varying load.

9. *Why is the size of this engine limited to* 3 *or* 4 *horse power?*

Because, as the capacity of the cylinder and the volume of the gases increase more rapidly than the circumference, the heat from the combustion increases more rapidly than the cooling surface to carry off the heat.

10. *Is there no other method of overcoming the difficulty in using gas for driving an engine?*

Yes, by preventing the sudden combustion of the combustible gases, or in other words, by prolonging the time of the explosion. This can be done by diluting the mixture of air and coal gas.

11. *Can a gas engine then be used to turn a crank and fly wheel like a steam engine?*

Yes, this has been carried out in a most ingenious manner by the inventors of the Otto and Langen

Atmospheric Gas Engine with complete success, a
with the further advantage of being practically noi
less. The noise made by the Atmospheric Gas Engi
is the only drawback to its more general adoption, :
in many places the noise it makes is lost in that of t
machinery it drives.

12. *For what work are gas engines eminen*
suited?

In nearly all cases where small power—up to 10 ho
power—is required at intervals only, and where t
facility of starting at a moment's notice is a gr
advantage. It can also be well adapted for supp
menting steam power—in factories, printing offic
&c., where its handiness will enable the attendance o
fireman or engineman, the working of a large boiler a
engine and the running of a lot of shafting to
dispensed with, in urgent cases where it is required
run a single light machine all night. It is also by
the readiest and cheapest engine for pumping water i
an accumulator where water-power is used in towns.

THE END.

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